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ABSTRACT

These instructional materials include a teacher's guide designed to assist instructors in organizing and presenting an introductory course in general electronics and a student guide. The materials are based on the curriculum-alignment concept of first stating the objectives, developing instructional strategies for teaching those objectives, and then evaluating based on the objectives. The course contains five units, each designed for use in more than one class period: Introduction to Electricity and Electronics, Shop Orientation and Safety, Fabrication and Repair, DC (direct current) and DC Circuits, and AC (alternating current) and AC Circuits. Each unit in the teacher edition includes some or all of the following: suggested activities, answers to assignment sheets, answers to written test, written test, unit evaluation form, teacher supplements, and transparency masters. In addition, the teacher edition includes a section on use of the publication, a competency profile, instructional and task analyses, academic and workplace skill classifications and definitions, a related academic and workplace skills list, and a correlation to the Electronics Industries Foundation skills list. Each of the five instructional units in the student edition includes some or all of the following components of a unit of instruction: objective sheet, information sheet, assignment sheets, and job sheets. (KC)

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ED 410 409

General Electronics Technician
Basic Electronics

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General Electronics Technician: Semiconductor Devices and Circuits

Teacher Edition

MAVCC

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General Electronics Technician:

Basic Electronics

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General Electronics Technician: Basic Electronics

Teacher Edition

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Foreword

General Electronics Technician: Basic Electronics is the first in a three-book series that has been developed to replace *Basic Electronics* and *General Electronics Technician*, MAVCC's popular core publications for electronics technology. This volume contains five units that address general electrical and electronic concepts, safety, tools, troubleshooting and repair, and DC and AC circuits. The other two books in the series are *General Electronics Technician: Semiconductor Devices and Circuits* and *General Electronics Technician: Digital Electronics and Introduction to Microprocessors*.

These new instructional materials acknowledge the expanding role of the electronics technician in this world of emerging technologies. They reflect technical developments in hardware and processes, as well as system changes within the industry, such as the increased role of microwave and fiber optic communications. They ensure that training needs as defined by industry are met by addressing the Electronic Industries Foundation proficiencies. Further, they incorporate improvements that MAVCC has made in our curriculum format to make the materials even more user-friendly and flexible while retaining the basic competency-based training concepts that have always been the foundation of MAVCC's instructional materials.

The success of this publication is due in large part to the capabilities of the personnel who worked in developing it. Appreciation is extended to them for their valuable contributions.

This series is designed for student use and to assist teachers in organizing and improving instruction. These instructional materials are based on the curriculum-alignment concept of first stating the objectives (objective sheet), developing instructional strategies for teaching to those objectives (information, assignment, and job sheets), and assessing to those same objectives (written test—a criterion-referenced evaluation instrument).

Every effort has been made to make these materials basic, readable, and usable. However, as with all instructional materials, teachers must localize and personalize these materials to meet their community, classroom/laboratory, and individual student's situation. Teachers are encouraged to supplement the materials and to develop strategies for motivating students.

Special attention should be given to the matrix identifying basic academic skills being reinforced in these instructional materials as well as the suggestions on ways to increase reinforcement of academic and workplace skills. By reinforcing these skills, the instructor should assist students in improving their employability skills.

As you use these instructional materials, we hope that you will find that they contribute to the quality of your program. If any problems occur or if you have any suggestions for improvement of the materials, please call or write us.

Jean McEntire, Chair
Board of Directors
Multistate Academic and
Vocational Curriculum Consortium

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Acknowledgments

All major development projects such as the *General Electronics Technician* series are the product of the contributions of many individuals. This is particularly true in this case because these new instructional materials build on the foundation of two other MAVCC products: *Basic Electronics* and *General Electronic Technician*. Thus, a large part of the credit for these new products is due to the people who originally worked on the predecessor materials.

Basic Electronics was written by Lonnie Hartman and coordinated by Jane Huston. The planning and review committee consisted of:

Ralph Albin	Kirksville, Missouri
Ron Archuleta	Aurora, Colorado
Bob Bixler	Austin, Texas
Don Grob	Salina, Kansas
Horace Hamby	Natchitoches, Louisiana
Lonnie Hartman	Stillwater, Oklahoma
Joe Johnson	Harrison, Arkansas
Mike Julsen	Mason City, Iowa
Marshall Pudwill	Bismark, North Dakota
Leander Stachura	Lincoln, Nebraska
Richard Stedman	Mitchell, South Dakota

General Electronics Technician was written by Ron Vorderstrasse and coordinated by Jane Huston under the guidance of the same committee that planned and reviewed *Basic Electronics*.

Committee members responsible for overseeing the development of this new series include:

Scott Brillhart	Tulsa, Oklahoma
Jim Bullington	Stillwater, Oklahoma
Stan Creitz	Beloit, Kansas
Bill Dews	Shreveport, Louisiana
Lonny Gibbs	Tulsa, Oklahoma
Victor Greenwood	Springdale, Arkansas
Chuck Robertson	Sioux Falls, South Dakota
Frank Secor	Bellaire, Texas
John Smith	Anchorage, Alaska
George Stevenson	Oregon City, Oregon

The new *General Electronics Technician* series was developed under contract with Robert Hilley, who served as the project's technical writer. John Brun did the copy and technical editing and provided invaluable technical support. Kim Patterson was responsible for typesetting and page layout. Nancy Hilley was the graphics coordinator and primary technical illustrator. The series also contains graphics from other sources as acknowledged in copyright

permission lines with the individual illustrations, as well as artwork from the original MAVCC publications that was generated by the Oklahoma Department of Vocational and Technical Education Graphics Division. The books were published by the Oklahoma Department of Vocational and Technical Education Print Shop, under the management of Danny Darrow.

Use of Introductory Materials

Introductory materials are included in the teacher edition only and contain useful information to assist administrators and teachers in planning for instruction.

In addition to the general information—such as the table of contents, foreword, and acknowledgments page—information is included on the following:

1. **Use of this publication**—Explains the components of a unit of instruction and how they should be used as part of the teaching/learning process.
2. **Competency profile**—Provides a record of student performance for each task included in a unit of instruction. This profile becomes a part of the student's permanent records and should be utilized when directing the student toward employment opportunities.
3. **Instructional/task analysis**—Provides a quick review of the contents of the publication; identifies cognitive (knowledge) skills and psychomotor (doing) skills addressed in each unit of instruction.
4. **Academic and workplace skill classifications and definitions**—Defines the basic-skill classifications used by MAVCC. Skill areas reflected by skill groups, subskills, and descriptions have been identified using *What Work Requires of Schools: A SCANS Report for America 2000* and *Workplace Basics: The Skills Employers Want*. These have been adapted by MAVCC.
5. **Related academic and workplace skills list**—Classifies unit tasks (assignment sheets and job sheets) according to the related academic and workplace skills being reinforced.
6. **Correlation to Electronics Industries Foundation skills list**—Shows how the competencies included in this publication satisfy the recommended training objectives developed by the Electronics Industries Foundation.

As you use these materials, it is hoped that they will provide useful information to meet a variety of needs.

Use of This Publication

Instructional units

General Electronics Technician: Basic Electronics contains five units of instruction:

- Unit 1—Introduction to Electricity and Electronics
- Unit 2—Shop Orientation and Safety
- Unit 3—Fabrication and Repair
- Unit 4—DC and DC Circuits
- Unit 5—AC and AC Circuits

Each instructional unit in a student edition includes some or all of the following components: objective sheet, information sheet, assignment sheets, and job sheets.

This teacher edition includes some or all of the following components for each of the five units of instruction: suggested activities, answers to assignment sheets, answers to written test, written test, unit evaluation form, teacher supplements, and transparency masters.

All of the unit components focus on measurable and observable learning outcomes. Teachers are encouraged to supplement, personalize, localize, and motivate with these materials in order to develop a complete teaching/learning process.

Units of instruction are designed for use in more than one lesson or class period of instruction. Careful study of each unit of instruction by the teacher will help to determine the following:

- Amount of materials that can be covered in each class period.
- Skills that must be demonstrated.
- Amount of class time needed for teacher demonstrations.
- Amount of class time needed for student practice.
- Supplementary materials, including print and nonprint media and equipment and supplies, that must be ordered.
- Resource persons who must be contacted.

Student-edition components

It is a challenge to keep students motivated. Instructors should supplement the student-edition components by providing the "why," personal experiences, and current information. Prepare for each unit by deciding how each component can best be taught. Allow students to become involved in preparing and planning their teaching/learning experiences.

Objective sheet. Each unit of instruction is based on performance objectives that state the goals for successful completion of the course. These performance objectives are stated in two forms: unit objectives, which state the expected performance of each student after completion of the unit of instruction, and specific objectives, which state what the student must do to reach the unit objective.

The objectives should be stressed throughout the teaching/learning process. This will help answer any questions concerning performance requirements for each instructional unit. The objectives can also help determine teaching strategies and instructional methods. Teachers should prepare for each unit by deciding how each objective can best be taught.

Teachers should feel free to modify, delete, or add objectives in order to meet the needs of the students and community. When objectives are added, the teacher should remember to supply the needed information-sheet, assignment-sheet, job-sheet, and written-test items.

Information sheet. The information sheet provides the content essential for meeting the cognitive (knowledge) objectives of the unit. Teachers will find that the information sheet serves as an excellent guide for presenting background knowledge necessary to develop the skills specified in the unit objective. Students should read the information sheet before the information is discussed in class. Space is provided in margins for students and teachers to add notes that supplement, localize, personalize, or provide information for the teaching of each objective.

Assignment sheets. Assignment sheets provide students with pencil-and-paper activities that give students the opportunity to make practical application of the knowledge in the information sheet. Criteria are provided to objectively evaluate student performance.

Job sheets. Job sheets are an important segment of each unit; they give the instructor direction as to the psychomotor skills to be taught and allow both the student and instructor to check student progress toward the accomplishment of those skills. Each job sheet provides criteria to allow the instructor to objectively evaluate student performance of a particular psychomotor skill. The instructor should discuss the equipment and materials to be used—emphasizing the specific equipment and materials available in the classroom and/or laboratory—and demonstrate the job-sheet procedure before having students practice the psychomotor skill.

Teacher-edition components

Suggested activities. The suggested activities assist teachers during the preparation stage of the teaching/learning process by providing an instructional plan, teaching suggestions, and a list of supplemental resources. Ways to integrate academic and workplace skills have been included in the teaching suggestions, and skill areas have been noted in bold. The teacher should read the suggested activities before teaching a unit and decide how each objective can best be taught. Time should also be allowed to obtain supplemental materials, prepare audiovisual materials, and contact outside resources. Duties of the teacher will vary according to the particular unit.

References used in the development of each unit are listed in the suggested-activities section, along with suggested supplemental resources that may be used to teach the unit. These materials can be used by the instructor to supplement her or his knowledge of the subject area or to help students with particular interests or objectives in the area covered.

The supplemental resources contain suggestions for media that the instructor may choose to use in support of the delivery portion of the teaching/learning process. Generally, none of the titles listed were more than approximately ten years old at the time of publication. This is done to provide the most current information in a contemporary style, as many students—especially adolescent students—may be distracted from the content of media by the presentation format, appearance of persons and equipment in the program, wear-and-tear of the physical medium, and other factors unrelated to the content information. However, many good films, videotapes, and similar media exist that were produced more than a decade ago, particularly those related to basic concepts such as Ohm's Law, electrical flow, fundamentals of semiconductor manufacture and common devices, etc. Instructors should assess the effectiveness of such programs within their specific course with their student population when selecting media to use.

Assignment-sheet and written-test answers. Assignment-sheet and written-test answers are designed to assist the teacher in evaluating student performances on the assignment sheets and written test.

Written test. This component is a criterion-referenced evaluation of every cognitive objective listed in the information sheet. It the instructor has added, deleted, or modified objectives, appropriate changes should be made on the written test. It is recommended that the test be divided into shorter tests covering three or four objectives at a time and given soon after those objectives are covered. A selection of test items from the units covered may be used for final tests at the end of each term if desired. The test is included in the teacher edition only, but duplication is permitted for student use.

Teacher supplements. Teacher supplements are optional materials for the teacher to use. They have three purposes: to provide the teacher with higher-level materials to stretch the advanced student, with remedial information or practice for the less-advanced student, and with state-of-the art information in which the instructor may not have background or with information that is not readily available in other sources. Some teacher supplements may be duplicated for student use and are marked accordingly.

Transparency masters. Transparency masters are used to direct the students' attention to the topic of discussion. Transparency masters may provide illustrations, chart, schematics, or additional information needed to clarify and reinforce objectives included in the unit of instruction.

General Electronics Technician:
Basic Electronics

Competency Profile

Name: ________________________________

Directions: Evaluate the student using one of the optional rating scales below. Write the appropriate numbers/letters to indicate the degree of competency achieved. The descriptions associated with each of the numbers/letters focus on a level of student performance for each of the tasks listed. The written-test score line is provided for optional teacher use. It may not be applicable in all cases.

Optional rating scales

Option A

Rating scale:
4 — **Skilled** - Can perform job with no additional training.
3 — **Moderately skilled** - Has performed job during training program; limited additional training may be required.
2 — **Limited skill** - Has performed job during training program; additional training is required to develop skill.
1 — **Unskilled** - Is familiar with process, but is unable to perform job.
0 — **No exposure** - No information or practice provided during training program; complete training is required.
NA — **Non-applicable.**

Option B

Yes — Can perform with no additional training
No — Is unable to perform satisfactorily

Unit 1: Introduction to Electricity and Electronics

______ 1. Apply Ohm's Law.
______ 2. Apply Watt's Law.
______ 3. Trace current flow in electrical circuits.
______ 4. Apply Kirchhoff's Laws.
______ 5. Apply the superposition theorem.
______ 6. Apply Thévenin's theorem.
______ 7. Convert electrical units of measure.
______ 8. Interpret electrical schematics.
______ 9. ____

______ Written-test score

Competency Profile

Unit 2: Shop Orientation and Safety

______ 1. Interpret Material Safety Data Sheets.
______ 2. Interpret safety symbols and colors
______ 3. Determine basic first-aid measures for emergency situations.
______ 4. Interpret meter readings.
______ 5. Calculate voltage from sine wave dimensions.
______ 6. Calculate time and frequency from waveform dimensions.
______ 7. Determine phase relationships of AC signals.
______ 8. Lift and move a heavy object.
______ 9. Operate a fire extinguisher.
______ 10. Handle and store flammable materials and toxic substances.
______ 11. Obtain tools from the tool crib.
______ 12. Measure electrical characteristics in a series circuit.
______ 13. Measure electrical characteristics in a parallel circuit
______ 14. Measure electrical characteristics in a series-parallel circuit.
______ 15. Adjust oscilloscope controls for a stable waveform display.
______ 16. Measure frequency using an oscilloscope.
______ 17. Measure AC voltage using an oscilloscope.
______ 18. Measure DC voltage using an oscilloscope.
______ 19. Calibrate an oscilloscope probe.
______ 20. ______________________________

______ Written-test score

Unit 3: Fabrication and Repair

______ 1. Use data books and other resources.
______ 2. Apply troubleshooting principles.
______ 3. Prepare a soldering iron tip for use.
______ 4. Adjust wire strippers.
______ 5. Cut and strip low-voltage wire and cable.
______ 6. Install coaxial cable connectors.
______ 7. Install ribbon cable connectors.
______ 8. Install crimp connectors on wires.
______ 9. Install soldered connectors on wires.
______ 10. Solder wires to turret terminals and desolder wires.
______ 11. Splice wires together by means of crimping.
______ 12. Splice wires together by means of soldering.
______ 13. Install components using mechanical fasteners.
______ 14. Install components using swaging.
______ 15. Form and tin leads on through-hole components.
______ 16. Install through-hole components on a circuit board.
______ 17. Install surface-mount components on a circuit board.

Competency Profile

______ 18. Remove through-hole components from a circuit board.
______ 19. Remove surface-mount components from a circuit board.
______ 20. Repair a printed circuit board.
______ 21. Inspect an electronic circuit and identify soldering and fabrication defects.
______ 22. ____

______ Written-test score

Unit 4: DC and DC Circuits

______ 1. Calculate resistance values from color codes.
______ 2. Determine total voltage in a series circuit.
______ 3. Determine voltage drops across resistances.
______ 4. Determine total resistance in a series circuit.
______ 5. Determine current in a series circuit.
______ 6. Compute power dissipated in a resistive series circuit.
______ 7. Calculate current and voltage in parallel circuits.
______ 8. Calculate resistance in parallel circuits.
______ 9. Calculate power in parallel circuits.
______ 10. Solve for branch voltages and currents in series-parallel circuits.
______ 11. Solve for total resistance in series-parallel circuits.
______ 12. Solve for total current in series-parallel circuits.
______ 13. Solve for total voltage in series-parallel circuits.
______ 14. Solve for total power in series-parallel circuits.
______ 15. Analyze DC circuits.
______ 16. Measure and compare current in a circuit at two different voltage levels.
______ 17. Wire a functional relay circuit.
______ 18. Measure the voltage drop in a DC circuit.
______ 19. Construct a voltage divider and analyze its function.
______ 20. Measure voltages in a balanced bridge circuit.
______ 21. Measure voltages in an unbalanced bridge circuit.
______ 22. Construct and operate a wheatstone bridge circuit.
______ 23. Determine the maximum power transfer point on a resistor circuit.
______ 24. Test and replace cells.
______ 25. Test and replace lamps.
______ 26. Test and replace switches.
______ 27. Test and replace resistors.
______ 28. Test and replace fuses and circuit breakers.
______ 29. Test and replace capacitors.
______ 30. Test and replace coils.
______ 31. Test and replace sensor devices.
______ 32. Test and replace relays.

______ 33. Test and replace solenoids.
______ 34. Troubleshoot DC circuits.
______ 35. ______________________________

______ Written-test score

Unit 5: AC and AC Circuits

______ 1. Determine sine wave conversions.
______ 2. Compute period.
______ 3. Determine current flow direction.
______ 4. Solve for total inductance.
______ 5. Compute inductive reactance.
______ 6. Compute applied voltage and impedance of RL circuits.
______ 7. Compute inductor quality.
______ 8. Solve time constant problems.
______ 9. Compute capacitance values.
______ 10. Compute RC time constants.
______ 11. Compute capacitive reactance.
______ 12. Determine phase relationships in RC circuits.
______ 13. Compute values of RC circuits.
______ 14. Solve for reactance.
______ 15. Solve for impedance.
______ 16. Solve for parameters of resonant circuits.
______ 17. Solve problems related to parallel RCL circuits.
______ 18. Analyze a parallel resonant circuit.
______ 19. Calculate the power in three-phase circuits
______ 20. Determine three-phase transformer connections
______ 21. Measure AC voltages using a multimeter
______ 22. Measure AC current using a multimeter
______ 23. Determine the configuration of a multiple-winding transformer
______ 24. Test and replace a transformer.
______ 25. Show the effect of inductance in AC circuits.
______ 26. Solve for values of an operating RL circuit.
______ 27. Test capacitors with an ohmmeter.
______ 28. Determine the effect of AC and DC on capacitors.
______ 29. Determine time constants of RC circuits.
______ 30. Construct a neon bulb flasher.
______ 31. Show the effect of capacitive reactance in AC circuits.
______ 32. Determine capacitive reactance and impedance in RC circuits.
______ 33. Determine resonance in a series RCL circuit.
______ 34. Determine the resonant frequency of an RCL parallel circuit.
______ 35. Troubleshoot AC circuits.
______ 36. ______________________________

______ Written-test score

Competency Profile

Comments: ____

____

Evaluator: ______________________________ **Date:** ______________

Permission to duplicate this profile is granted.

General Electronics Technician:
Basic Electronics

Instructional/Task Analysis

Related Information: What the student should know	Application: What the student should be able to do
Unit 1: Introduction to Electricity and Electronics	
1. Definitions of terms associated with electricity and electronics	
2. Areas of employment in the electronics industry	
3. Areas of scientific study in the electronics industry	
4. The electron theory of electricity	
5. Electrical characteristics of conductors, insulators, and semiconductors	
6. Sources of electricity	
7. Characteristics of electrical flow	
8. Units of measure, their abbreviations, and symbols for characteristics of electrical flow	
9. Ohm's Law for calculating values of given characteristics of electrical flow	
10. Watt's Law for calculating power	
11. Forms of electrical current	
12. Parts of a simple electrical circuit	
13. Types of electrical circuit power sources	

Related Information: What the student should know	Application: What the student should be able to do
Unit 1: Introduction to Electricity and Electronics (cont.)	
14. Purpose of the ground in an electrical circuit	
15. Types of grounds used with electronic equipment	
16. Symbols for types of grounds used with electronic equipment	
17. Classifications of electrical/electronic circuits	
18. The flow of electricity in a series circuit	
19. Electrical characteristics in a series circuit	
20. The flow of electricity in a parallel circuit	
21. Electrical characteristics in a parallel circuit	
22. The flow of electricity in a series-parallel circuit	
23. Electrical characteristics in a series-parallel circuit	
24. Kirchhoff's first law regarding current in a circuit	
25. Kirchhoff's second law regarding voltage in a circuit	
26. The principle of maximum power transfer	
27. The Superposition Theorem	

Related Information: What the student should know	Application: What the student should be able to do
Unit 1: Introduction to Electricity and Electronics (cont.)	
28. Thévenin's Theorem	
29. Electrical components commonly used in electronic equipment	
30. Symbols for electrical components commonly used in electronic equipment	
31. Difference in purposes of electrical circuits and electronic circuits	
32. Types of information that can be represented by electronic signals	
33. Two types of electronic signals	
34. Three categories of electronic devices	
35. Four main functions of electronic devices	
36. Functions of electronic devices	
37. Symbols for electronic devices	
38. Magnetic properties of substances	
39. Classifications of substances based on their magnetic properties	
40. Ways of classifying magnets	
41. Facts about magnetic flux lines	
42. Facts about electromagnetism	
43. The principle of induction	

Instructional/Task Analysis

Unit 1: Introduction to Electricity and Electronics (cont.)

Related Information: What the student should know		Application: What the student should be able to do	
44.	Factors that influence the amount of current produced through induction	46.	Apply Ohm's Law
		47.	Apply Watt's Law
45.	Prefixes and symbols used with electrical and electronic terms to show decimal and powers of ten values	48.	Trace current flow in electrical circuits
		49.	Apply Kirchhoff's Laws
		50.	Apply the superposition theorem
		51.	Apply Thévenin's theorem
		52.	Convert electrical units of measure
		53.	Interpret electrical schematics

Unit 2: Shop Orientation and Safety

Related Information: What the student should know		Application: What the student should be able to do	
1.	Definitions of terms associated with shop orientation and safety		
2.	Parts of a typical electronics workstation		
3.	Functions of the parts of a typical electronics workstation		
4.	Types of damage that can occur to electrostatic-sensitive devices		
5.	Conditions that promote electrostatic discharge		
6.	Methods for reducing and monitoring electrostatic discharge		
7.	Types of general hand tools used in the electronics workplace		

Related Information: What the student should know	Application: What the student should be able to do
Unit 2: Shop Orientation and Safety (cont.)	
8. Uses of general hand tools in the electronics workplace	
9. Uses of wire preparation and assembly tools	
10. Uses of soldering tools	
11. Uses of electronic component handling and preparation tools	
12. Uses of types of electronic test equipment and inspection tools	
13. Types of meters	
14. Types of analog meter movements	
15. Characteristics and operation of an ammeter	
16. Characteristics and operation of a voltmeter	
17. Characteristics and operation of an ohmmeter	
18. Operation of a digital meter	
19. Functions of oscilloscope controls	
20. Operation of an oscilloscope	
21. Measurements that can be made with an oscilloscope	
22. Parts of a waveform display	

Related Information: What the student should know

Application: What the student should be able to do

Unit 2: Shop Orientation and Safety (cont.)

23. Applications of chemicals used in the electronics workplace
24. Types of hazards that may be encountered in an electronics shop
25. Rules for maintaining a safe work area
26. Statements regarding general workplace safety
27. Roles of agencies involved in overseeing safety and public safety in the electronics workplace
28. Meanings of safety code colors
29. Electrical hazards in the electronics workplace
30. Statements about electrical shock.
31. Steps in treating victims of electrical shock
32. Descriptions of chemical hazards in the electronics workplace
33. Ways in which chemicals can enter the body
34. Classes of fires
35. High energy hazards in the electronics workplace
36. Interpret Material Safety Data Sheets
37. Interpret safety symbols and colors
38. Determine basic first-aid measures for emergency situations
39. Interpret meter readings
40. Calculate voltage from sine wave dimensions
41. Calculate time and frequency from waveform dimensions
42. Determine phase relationships of AC signals
43. Lift and move a heavy object
44. Operate a fire extinguisher
45. Handle and store flammable materials and toxic substances
46. Obtain tools from the tool crib
47. Measure electrical characteristics in a series circuit
48. Measure electrical characteristics in a parallel circuit
49. Measure electrical characteristics in a series-parallel circuit
50. Adjust oscilloscope controls for a stable waveform display

Instructional/Task Analysis

Related Information: What the student should know	Application: What the student should be able to do
Unit 2: Shop Orientation and Safety (cont.)	
	51. Measure frequency using an oscilloscope
	52. Measure AC voltage using an oscilloscope
	53. Measure DC voltage using an oscilloscope
	54. Calibrate an oscilloscope probe
Unit 3: Fabrication and Repair	
1. Definitions of terms associated with soldering and fabrication	
2. Methods of electronic circuitry fabrication	
3. Component and material preparation steps	
4. Materials used in electronic circuitry fabrication	
5. Types of wires and cables used in electronic circuitry fabrication	
6. Types of connectors used in electronic circuitry fabrication	
7. Methods for installing connectors	
8. Reasons for lead-forming electronic components	
9. Reasons for tinning electronic components	

Instructional/Task Analysis

Related Information: What the student should know

Application: What the student should be able to do

Unit 3: Fabrication and Repair (cont.)

10. Goals for soldered connections
11. Statements about solder and flux
12. Guidelines for proper hand soldering
13. Solder joints
14. Types of solder defects
15. Methods of removing installed components
16. Parts of a printed circuit board
17. Types of printed circuit board construction
18. Types of printed circuit board materials
19. Printed circuit board coatings
20. Methods of removing printed circuit board coatings
21. General steps for troubleshooting

22. Use data books and other resources
23. Apply troubleshooting principles
24. Prepare a soldering iron tip for use
25. Adjust wire strippers
26. Cut and strip low-voltage wire and cable
27. Install coaxial cable connectors
28. Install ribbon cable connectors
29. Install crimp connectors on wires
30. Install soldered connectors on wires
31. Solder wires to turret terminals and desolder wires
32. Splice wires together by means of crimping
33. Splice wires together by means of soldering
34. Install components using mechanical fasteners
35. Install components using swaging
36. Form and tin leads on through-hole components
37. Install through-hole components on a circuit board

Instructional/Task Analysis

Related Information: What the student should know	Application: What the student should be able to do
Unit 3: Fabrication and Repair (cont.)	
	38. Install surface-mount components on a circuit board
	39. Remove through-hole components from a circuit board
	40. Remove surface-mount components from a circuit board
	41. Repair a printed circuit board
	42. Inspect an electronic circuit and identify soldering and fabrication defects
Unit 4: DC and DC Circuits	
1. Definitions of terms associated with DC and DC circuits	
2. Reason for using direct current in electronic equipment	
3. Methods for providing direct current for electronic equipment	
4. Functions of common types of DC circuit components	
5. Ways of classifying batteries	
6. Descriptions of lamps used in DC circuits	
7. Symbols for lamps used in DC circuits	
8. Descriptions of switches used in DC circuits	

Instructional/Task Analysis

Related Information: What the student should know	Application: What the student should be able to do
Unit 4: DC and DC Circuits (cont.)	
9. Symbols for switches used in DC circuits	
10. Methods for manually actuating switches	
11. Circuit protection devices used in DC circuits	
12. Circuit protection devices used in DC circuits	
13. Symbols for circuit protection devices used in DC circuits	
14. Types of resistors used in DC circuits	
15. Resistors used in DC circuits	
16. Symbols for resistors used in DC circuits	
17. Meanings of color bands on a resistor	
18. Meanings of colors used on resistors	
19. Inductors used in DC circuits	
20. Symbols for inductors used in DC circuits	
21. The left-hand rule for conductors	
22. The left-hand rule for coils	
23. Sensor devices used in DC circuits	

Related Information: What the student should know

Application: What the student should be able to do

Unit 4: DC and DC Circuits (cont.)

24. Symbols for sensor devices used in DC circuits
25. Relays used in DC circuits
26. Symbols for relays used in DC circuits
27. Characteristics of voltage dividers
28. Operation of loaded and unloaded voltage dividers
29. Types of bridge circuits
30. Schematics for types of bridge circuits

31. Calculate resistance values from color codes
32. Determine total voltage in a series circuit
33. Determine voltage drops across resistances
34. Determine total resistance in a series circuit
35. Determine current in a series circuit
36. Compute power dissipated in a resistive series circuit
37. Calculate current and voltage in parallel circuits
38. Calculate resistance in parallel circuits
39. Calculate power in parallel circuits
40. Solve for branch voltages and currents in series-parallel circuits
41. Solve for total resistance in series-parallel circuits
42. Solve for total current in series-parallel circuits
43. Solve for total voltage in series-parallel circuits
44. Solve for total power in series-parallel circuits
45. Analyze DC circuits

Related Information: What the student should know	Application: What the student should be able to do

Unit 4: DC and DC Circuits (cont.)

	46. Measure and compare current in a circuit at two different voltage levels
	47. Wire a functional relay circuit
	48. Measure the voltage drop in a DC circuit
	49. Construct a voltage divider and analyze its function
	50. Measure voltages in a balanced bridge circuit
	51. Measure voltages in an unbalanced bridge circuit
	52. Construct and operate a wheatstone bridge circuit
	53. Determine the maximum power transfer point on a resistor circuit
	54. Test and replace cells
	55. Test and replace lamps
	56. Test and replace switches
	57. Test and replace resistors
	58. Test and replace fuses and circuit breakers
	59. Test and replace capacitors
	60. Test and replace coils
	61. Test and replace sensor devices

Instructional/Task Analysis

Related Information: What the student should know	Application: What the student should be able to do
Unit 4: DC and DC Circuits (cont.)	
	62. Test and replace relays
	63. Test and replace solenoids
	64. Troubleshoot DC circuits
Unit 5: AC and AC Circuits	
1. Definitions of terms associated with alternating current and AC circuits	
2. Role of alternating current in the operation of electronic equipment	
3. Methods for providing safety grounding for AC circuits	
4. Characteristics of an AC waveform	
5. Differences between sinusoidal and nonsinusoidal waveforms	
6. AC waveform phase relationships	
7. Phase angles of various types of circuits	
8. Statements regarding inductance	
9. Process of self-induction	
10. Relationship between current and voltage in an inductive AC circuit	
11. Power in an inductive circuit	
12. Operation of a generator	
13. Operation of an AC motor	

Instructional/Task Analysis

Related Information: What the student should know	Application: What the student should be able to do

Unit 5: AC and AC Circuits (cont.)

14. Roles of transformers in the operation of electronic equipment
15. Types of transformers
16. Types of three-phase circuits
17. Types of single-phase transformer connections
18. Time constant of inductive circuits
19. Statements about inductive reactance
20. Process of mutual induction
21. Factors that influence the strength of inductors
22. Statements regarding the quality of inductors
23. Formulas for connecting inductors in series and parallel
24. Relationship between current and voltage in an RL circuit
25. Impedance in RL circuits
26. Formula for determining phase shift in RL circuits
27. Statements regarding capacitance
28. Factors that influence the capacitance of a capacitor
29. Ways of classifying capacitors

Instructional/Task Analysis

Related Information: What the student should know	Application: What the student should be able to do

Unit 5: AC and AC Circuits (cont.)

Related Information: What the student should know	Application: What the student should be able to do
30. Uses of capacitors in electronic circuits	
31. Capacitor defects	
32. Rules for connecting capacitors in series and parallel	
33. Time constants in an RC circuit	
34. Relationship between current and voltage in an RC circuit	
35. Power in an RC circuit	
36. Impedance in RC circuits	
37. Formula for determining phase shift in RC circuits	
38. Statements regarding capacitive reactance	
39. Formulas used to determine the characteristics of series RC circuits	
40. Formulas used to determine the characteristics of parallel RC circuits	
41. Uses of capacitive circuits	
42. Characteristics of series RCL circuits	
43. Resonant characteristics of a series RCL circuit	
44. Characteristics of parallel RCL circuits	

Unit 5: AC and AC Circuits (cont.)

Related Information: What the student should know

45. Descriptions of the resonant characteristics of a parallel RCL circuit
46. Processes for conditioning signals
47. Devices and circuits involved in analog signal conditioning
48. Devices and circuits involved in digital signal conditioning
49. AC differentiator and integrator circuits
50. Configurations of filter circuits
51. Operation of types of filter circuits
52. Differences between the operation of a high-pass filter and a low-pass filter
53. Guidelines for impedance matching
54. Statements regarding rectangular notation
55. Complete statements regarding polar notation

Application: What the student should be able to do

56. Determine sine wave conversions
57. Compute period
58. Determine current flow direction
59. Solve for total inductance
60. Compute inductive reactance
61. Compute applied voltage and impedance of RL circuits
62. Compute inductor quality
63. Solve time constant problems
64. Compute capacitance values
65. Compute RC time constants
66. Compute capacitive reactance
67. Determine phase relationships in RC circuits
68. Compute values of RC circuits
69. Solve for reactance
70. Solve for impedance
71. Solve for parameters of resonant circuits
72. Solve problems related to parallel RCL circuits
73. Analyze a parallel resonant circuit

Related Information: What the student should know	Application: What the student should be able to do

Unit 5: AC and AC Circuits (cont.)

74. Calculate the power in three-phase circuits

75. Determine three-phase transformer connections

76. Measure AC voltages using a multimeter

77. Measure AC current using a multimeter

78. Determine the configuration of a multiple-winding transformer

79. Test and replace a transformer

80. Show the effect of inductance in AC circuits

81. Solve for values of an operating RL circuit

82. Test capacitors with an ohmmeter

83. Determine the effect of AC and DC on capacitors

84. Determine time constants of RC circuits

85. Construct a neon bulb flasher

86. Show the effect of capacitive reactance in AC circuits

87. Determine capacitive reactance and impedance in RC circuits

Related Information: What the student should know	Application: What the student should be able to do
Unit 5:	**AC and AC Circuits** (cont.)
	88. Determine resonance in a series RCL circuit
	89. Determine the resonant frequency of an RCL parallel circuit
	90. Troubleshoot AC circuits

Academic and Workplace Skill Classifications and Definitions

Skill group	Subskill	Definition
Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
	Writing	Communicating a thought, idea, or fact in written form in a clear, concise manner.
	Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
	Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Listening	Receiving, interpreting, and responding to verbal messages and other cues.
	Speaking	Communicating a thought, idea, or fact verbally in a clear, concise manner.
Thinking skills	Creative thinking	Using imagination to generate new ideas.
	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results.
	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
	Knowing how to learn	Using efficient learning techniques to acquire and apply new knowledge and skills.
	Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
	Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Career awareness, development, and mobility	Assessing self accurately, setting personal goals, establishing and implementing a plan, and monitoring progress.
	Integrity/honesty	Choosing an ethical course of action when faced with making a decision that may break with personal and societal values and recognizing the impact of violating these beliefs and codes on an organization, self, and others.
	Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.

Academic and Workplace Skill Classifications and Definitions

Skill group	Subskill	Definition
Interpersonal skills	Teamwork	Working cooperatively with others to reach a common goal.
	Coaching	Helping others learn new skills.
	Leadership	Communicating ideas to justify position; accepting responsibility for others; and encouraging, persuading, convincing, or otherwise motivating an individual or group.
	Negotiation	Resolving conflict between two or more individuals through discussion and compromise.
	Customer service	Working and communicating with customers to satisfy their expectations.
	Cultural diversity	Working well with men and women and with a variety of ethnic, social, or educational backgrounds.
Resources	Time	Selecting relevant, goal-oriented activities, ranking them in order of importance, allocating time, and understanding, preparing, and following schedules.
	Money	Using or preparing budgets, making forecasts, keeping records, and making adjustments to meet objectives.
	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Human resources	Assessing skills and distributing work accordingly; evaluating performance and providing feedback.
Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
	Organization and storage	Organizing, processing, and maintaining written or computerized records and other forms of information in a systematic way.
	Interpretation	Selecting and analyzing information and communicating the results to others.
	Processing	Using computers to acquire, organize, analyze, and communicate information.
Systems	Interrelationships	Knowing how social, organizational, and technological systems work and operate effectively.
	Monitoring	Distinguishing trends, predicting impact of actions on system operations, diagnosing deviations in systems' performance, and correcting malfunctions.
	Modification and design	Making suggestions to modify existing systems to improve products or services, and developing new or alternative systems.
Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
	Application	Demonstrating proper procedures for setting up and operating equipment.
	Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment, including computers and other technologies.

General Electronics Technician:
Basic Electronics

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
Unit 1:	**Introduction to Electricity and Electronics**		
Apply Ohm's Law (A.S. 1)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Apply Watt's Law (A.S. 2)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Trace current flow in electrical circuits (A.S. 3)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.

Related Academic and Workplace Skills List

Unit 1: Introduction to Electricity and Electronics (cont.)

Task	Skill group	Subskill	Description
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Systems	Interrelationships	Knowing how social, organizational, and technological systems work and operate effectively.
Apply Kirchhoff's Laws (A.S. 4)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinkng skills	Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Systems	Interrelationships	Knowing how social, organizational, and technological systems work and operate effectively.
Apply the superposition theorem (A.S. 5)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
Unit 1: Introduction to Electricity and Electronics (cont.)			
	Thinking skills	Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Systems	Interrelationships	Knowing how social, organizational, and technological systems work and operate effectively.
Apply Thévenin's theorem (A.S. 6)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Systems	Interrelationships	Knowing how social, organizational, and technological systems work and operate effectively.
Convert electrical units of measure (A.S. 7)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
Unit 1: Introduction to Electricity and Electronics (cont.)			
	Thinking skills	Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Systems	Interrelationships	Knowing how social, organizational, and technological systems work and operate effectively.
Interpret electrical schematics (A.S. 8)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
	Thinking skills	Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Systems	Interrelationships	Knowing how social, organizational, and technological systems work and operate effectively.
Unit 2: Shop Orientation and Safety			
Interpret Material Safety Data Sheets (A.S. 1)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Writing	Communicating a thought, idea, or fact in written form in a clear, concise manner.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
Unit 2: Shop Orientation and Safety (cont.)			
		Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
		Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.
Interpret safety symbols and colors (A.S. 2)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Writing	Communicating a thought, idea, or fact in written form in a clear, concise manner.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
		Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
		Interpretation	Selecting and analyzing information and communicating the results to others.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
Unit 2: Shop Orientation and Safety (cont.)			
Determine basic first-aid measures for emergency situations (A.S. 3)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Writing	Communicating a thought, idea, or fact in written form in a clear, concise manner.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
		Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
		Interpretation	Selecting and analyzing information and communicating the results to others.
Interpret meter readings (A.S. 4)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
Unit 2: Shop Orientation and Safety (cont.)			
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Information	Interpretation	Selecting and analyzing information and communicating the results to others.
Calculate voltage from sine wave dimensions (A.S. 5)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Information	Interpretation	Selecting and analyzing information and communicating the results to others.
Calculate time and frequency from waveform dimensions (A.S. 6)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
Unit 2: Shop Orientation and Safety (cont.)			
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
		Interpretation	Selecting and analyzing information and communicating the results to others.
Determine phase relationships of AC signals (A.S. 7)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Information	Interpretation	Selecting and analyzing information and communicating the results to others.
Lift and move a heavy object (J.S. 1)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.

Related Academic and Workplace Skills List

Unit 2: Shop Orientation and Safety (cont.)

Task	Skill group	Subskill	Description
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
		Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.
	Interpersonal skills	Teamwork	Working cooperatively with others to reach a common goal.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
Operate a fire extinguisher (J.S. 2)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
		Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
		Interpretation	Selecting and analyzing information and communicating the results to others.
Handle and store flammable materials and toxic substances (J.S. 3)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
Unit 2: Shop Orientation and Safety (cont.)			
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
		Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
		Interpretation	Selecting and analyzing information and communicating the results to others.
Obtain tools from the tool crib (J.S. 4)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Listening	Receiving, interpreting, and responding to verbal messages and other cues.
		Speaking	Communicating a thought, idea, or fact verbally in a clear, concise manner.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
Unit 2: Shop Orientation and Safety (cont.)			
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
		Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Information	Interpretation	Selecting and analyzing information and communicating the results to others.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Measure electrical characteristics in a series circuit (J.S. 5)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
		Speaking	Communicating a thought, idea, or fact verbally in a clear, concise manner.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
Unit 2: Shop Orientation and Safety (cont.)			
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
		Interpretation	Selecting and analyzing information and communicating the results to others.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Measure electrical characteristics in a parallel circuit (J.S. 6)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
		Speaking	Communicating a thought, idea, or fact verbally in a clear, concise manner.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
		Interpretation	Selecting and analyzing information and communicating the results to others.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
Unit 2: Shop Orientation and Safety (cont.)			
Measure electrical characteristics in a series-parallel circuit (J.S. 7)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
		Speaking	Communicating a thought, idea, or fact verbally in a clear, concise manner.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
		Interpretation	Selecting and analyzing information and communicating the results to others.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Adjust oscilloscope controls for a stable waveform display (J.S. 8)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
Unit 2: Shop Orientation and Safety (cont.)			
		Speaking	Communicating a thought, idea, or fact verbally in a clear, concise manner.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Measure frequency using an oscilloscope (J.S. 9)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
		Speaking	Communicating a thought, idea, or fact verbally in a clear, concise manner.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
Unit 2: Shop Orientation and Safety (cont.)			
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
		Interpretation	Selecting and analyzing information and communicating the results to others.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Measure AC voltage using an oscilloscope (J.S. 10)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
		Speaking	Communicating a thought, idea, or fact verbally in a clear, concise manner.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
		Interpretation	Selecting and analyzing information and communicating the results to others.

Related Academic and Workplace Skills List

Unit 2: Shop Orientation and Safety (cont.)

Task	Skill group	Subskill	Description
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Measure DC voltage using an oscilloscope (J.S. 11)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
		Speaking	Communicating a thought, idea, or fact verbally in a clear, concise manner.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
		Interpretation	Selecting and analyzing information and communicating the results to others.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Calibrate an oscilloscope probe (J.S. 12)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.

Unit 2: Shop Orientation and Safety (cont.)

Task	Skill group	Subskill	Description
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
		Speaking	Communicating a thought, idea, or fact verbally in a clear, concise manner.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment, including computers and other technologies.

Unit 3: Fabrication and Repair

Task	Skill group	Subskill	Description
Use data books and other resources (A S 1)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Writing	Communicating a thought, idea, or fact in written form in a clear, concise manner.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
	Unit 3:	**Fabrication and Repair** (cont.)	
		Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
		Interpretation	Selecting and analyzing information and communicating the results to others.
Apply troubleshooting principles (A.S. 2)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Writing	Communicating a thought, idea, or fact in written form in a clear, concise manner.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.

Task	Skill group	Subskill	Description
Unit 3:	**Fabrication and Repair** (cont.)		
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
		Interpretation	Selecting and analyzing information and communicating the results to others.
Prepare a soldering iron tip for use (J.S. 1)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
		Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment, including computers and other technologies.
Adjust wire strippers (J.S. 2)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.

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Task	Skill group	Subskill	Description
Unit 3:	**Fabrication and Repair** (cont.)		
		Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Cut and strip low-voltage wire and cable (J.S. 3)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
		Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Install coaxial cable connectors (J.S. 4)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
Unit 3:	**Fabrication and Repair** (cont.)		
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
		Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Install ribbon cable connectors (J.S. 5)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.

Task	Skill group	Subskill	Description
Unit 3:	**Fabrication and Repair** (cont.)		
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
		Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Install crimp connectors on wires (J.S. 6)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.

Unit 3: **Fabrication and Repair** (cont.)

Task	Skill group	Subskill	Description
		Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Install soldered connectors on wires (J.S. 7)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
		Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
	Unit 3:	**Fabrication and Repair** (cont.)	
		Application	Demonstrating proper procedures for setting up and operating equipment.
Solder wires to turret terminals and desolder wires (J.S. 8)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
		Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Splice wires together by means of crimping (J.S. 9)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
	Unit 3:	**Fabrication and Repair** (cont.)	
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
		Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Splice wires together by means of soldering (J.S. 10)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
Unit 3: Fabrication and Repair (cont.)			
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
		Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Install components using mechanical fasteners (J.S. 11)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
		Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.

Task	Skill group	Subskill	Description
Unit 3: Fabrication and Repair (cont.)			
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Install components using swaging (J.S. 12)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
		Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
	Unit 3:	**Fabrication and Repair** (cont.)	
Form and tin leads on through-hole components (J.S. 13)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
		Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Install through-hole components on a circuit board (J.S. 14)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
	Unit 3:	**Fabrication and Repair** (cont.)	
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
		Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Install surface-mount components on a circuit board (J.S. 15)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
	Unit 3:	**Fabrication and Repair** (cont.)	
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
		Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Remove through-hole components from a circuit board (J.S. 16)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
		Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
Unit 3: Fabrication and Repair (cont.)			
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment, including computers and other technologies.
Remove surface-mount components from a circuit board (J.S. 17)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
		Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
Unit 3: Fabrication and Repair (cont.)			
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment, including computers and other technologies.
Repair a printed circuit board (J.S. 18)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
		Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
	Unit 3:	**Fabrication and Repair** (cont.)	
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment, including computers and other technologies.
Inspect an electronic circuit and identify soldering and fabrication defects (J.S. 19)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Creative thinking	Use imagination to create new ideas.
		Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
		Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
		Interpretation	Selecting and analyzing information and communicating the results to others.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.

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Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
Unit 4: DC and DC Circuits			
Calculate resistance values from color codes (A.S. 1)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
Determine total voltage in a series circuit (A.S. 2)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Determine voltage drops across resistances (A.S. 3)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.

Related Academic and Workplace Skills List

Unit 4: DC and DC Circuits (cont.)

Task	Skill group	Subskill	Description
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Determine total resistance in a series circuit (A.S. 4)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Determine current in a series circuit (A.S. 5)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
	Unit 4:	**DC and DC Circuits**	(cont.)
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Compute power dissipated in a resistive series circuit. (A.S. 6)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Calculate current and voltage in parallel circuits. (A.S. 7)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
	Unit 4: DC and DC Circuits (cont.)		
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Calculate resistance in parallel circuits (A.S. 8)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Calculate power in parallel circuits (A.S. 9)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
	Unit 4:	**DC and DC Circuits** (cont.)	
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Solve for branch voltages and currents in series-parallel circuits (A.S. 10)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Solve for total resistance in series-parallel circuits (A.S. 11)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
Unit 4: DC and DC Circuits (cont.)			
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Solve for total current in series-parallel circuits (A.S. 12)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Solve for total voltage in series-parallel circuits (A.S. 13)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
Unit 4: DC and DC Circuits (cont.)			
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Solve for total power in series-parallel circuits (A.S. 14)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Analyze DC circuits (A.S. 15)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Writing	Communicating a thought, idea, or fact in written form in a clear, concise manner.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
	Unit 4: DC and DC Circuits (cont.)		
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Measure and compare current in a circuit at two different voltage levels (J.S. 1)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Wire a functional relay circuit (J.S. 2)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
	Unit 4: DC and DC Circuits (cont.)		
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Measure the voltage drop in a DC circuit (J.S. 3)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
	Unit 4:	**DC and DC Circuits**	(cont.)
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Construct a voltage divider and analyze its function (J.S. 4)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Measure voltages in a balanced bridge circuit (J.S. 5)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
	Unit 4: DC and DC Circuits (cont.)		
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Measure voltages in an unbalanced bridge circuit (J.S. 6)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
	Unit 4: DC and DC Circuits (cont.)		
		Application	Demonstrating proper procedures for setting up and operating equipment.
Construct and operate a wheatstone bridge circuit (J.S. 7)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Determine the maximum power transfer point on a resistor circuit (J.S. 8)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
	Unit 4: DC and DC Circuits (cont.)		
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Test and replace cells (J.S. 9)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
Unit 4:	**DC and DC Circuits**	(cont.)	
		Application	Demonstrating proper procedures for setting up and operating equipment.
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment, including computers and other technologies.
Test and replace lamps (J.S. 10)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment, including computers and other technologies.
Test and replace switches (J.S. 11)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
	Unit 4:	**DC and DC Circuits** (cont.)	
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment, including computers and other technologies.
Test and replace resistors (J.S. 12)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.

Task	Skill group	Subskill	Description
	Unit 4: DC and DC Circuits (cont.)		
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment, including computers and other technologies.
Test and replace fuses and circuit breakers (J.S. 13)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
	Unit 4: DC and DC Circuits (cont.)		
		Application	Demonstrating proper procedures for setting up and operating equipment.
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment, including computers and other technologies.
Test and replace capacitors (J.S. 14)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment, including computers and other technologies.
Test and replace coils (J.S. 15)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
	Unit 4:	**DC and DC Circuits** (cont.)	
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment, including computers and other technologies.
Test and replace sensor devices (J.S. 16)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.

Task	Skill group	Subskill	Description
	Unit 4: DC and DC Circuits (cont.)		
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment, including computers and other technologies.
Test and replace relays (J.S. 17)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.

Related Academic and Workplace Skills List

Unit 4: DC and DC Circuits (cont.)

Task	Skill group	Subskill	Description
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment, including computers and other technologies.
Test and replace solenoids (J.S. 18)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
	Unit 4:	**DC and DC Circuits** (cont.)	
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment, including computers and other technologies.
Troubleshoot DC circuit (J.S. 19)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Writing	Communicating a thought, idea, or fact in written form in a clear, concise manner.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
		Listening	Receiving, interpreting, and responding to verbal messages and other cues.
		Speaking	Communicating a thought, idea, or fact verbally in a clear, concise manner.
	Thinking skills	Creative thinking	Using imagination to generate new ideas.
		Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
		Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.
	Resources	Time	Selecting relevant, goal-oriented activities, ranking them in order of importance, allocating time, and understanding, preparing, and following schedules.
		Material and facilities	Acquiring, storing, and using materials and space efficiently.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
Unit 4: DC and DC Circuits (cont.)			
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
		Interpretation	Selecting and analyzing information and communicating the results to others.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment, including computers and other technologies.
Unit 5: AC and AC Circuits			
Determine sine wave conversions (A.S. 1)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Compute period (A.S. 2)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
	Unit 5:	**AC and AC Circuits** (cont.)	
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Determine current flow direction (A.S. 3)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Solve for total inductance (A.S. 4)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
Unit 5: AC and AC Circuits (cont.)			
Compute inductive reactance (A.S. 5)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Compute applied voltage and impedance of RL circuits (A.S. 6)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Compute inductor quality (A.S. 7)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.

Related Academic and Workplace Skills List

Unit 5: AC and AC Circuits (cont.)

Task	Skill group	Subskill	Description
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Solve time constant problems (A.S. 8)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
Unit 5: AC and AC Circuits (cont.)			
Compute capacitance values (A.S. 9)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Compute RC time constants (A.S. 10)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Compute capacitive reactance (A.S. 11)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.

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Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
	Unit 5: AC and AC Circuits (cont.)		
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Determine phase relationships in RC circuits (A.S. 12)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Compute values of RC circuits (A.S. 13)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
Unit 5: AC and AC Circuits (cont.)			
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Solve for reactance (A.S. 14)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Solve for impedance (A.S. 15)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
Unit 5: AC and AC Circuits (cont.)			
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Solve for parameters of resonant circuits (A.S. 16)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Solve problems related to parallel RCL circuits (A.S. 17)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
	Unit 5: AC and AC Circuits (cont.)		
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Analyze a parallel resonant circuit (A.S. 18)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Calculate the power in three-phase circuits (A.S. 19)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
	Unit 5: AC and AC Circuits (cont.)		
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Determine three-phase transformer connections (A.S. 20)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
Measure AC voltages using a multimeter (J.S. 1)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
		Listening	Receiving, interpreting, and responding to verbal messages and other cues.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
	Unit 5:	**AC and AC Circuits** (cont.)	
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Measure AC current using a multimeter (J.S. 2)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
Determine the configuration of a multiple-winding transformer (J.S. 3)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Listening	Receiving, interpreting, and responding to verbal messages and other cues.
		Speaking	Communicating a thought, idea, or fact verbally in a clear, concise manner.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
	Unit 5: AC and AC Circuits (cont.)		
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Test and replace a transformer (J.S. 4)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Listening	Receiving, interpreting, and responding to verbal messages and other cues.
		Speaking	Communicating a thought, idea, or fact verbally in a clear, concise manner.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
	Unit 5: AC and AC Circuits (cont.)		
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment, including computers and other technologies.
Show the effect of inductance in AC circuits (J.S. 5)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
		Listening	Receiving, interpreting, and responding to verbal messages and other cues.
		Speaking	Communicating a thought, idea, or fact verbally in a clear, concise manner.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Solve for values of an operating RL circuit (J.S. 6)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
	Unit 5: AC and AC Circuits (cont.)		
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
		Listening	Receiving, interpreting, and responding to verbal messages and other cues.
		Speaking	Communicating a thought, idea, or fact verbally in a clear, concise manner.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Test capacitors with an ohmmeter (J.S. 7)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Listening	Receiving, interpreting, and responding to verbal messages and other cues.
		Speaking	Communicating a thought, idea, or fact verbally in a clear, concise manner.
	Thinking skills	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
	Unit 5: AC and AC Circuits (cont.)		
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment, including computers and other technologies.
Determine the effect of AC and DC on capacitors (J.S. 8)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
		Listening	Receiving, interpreting, and responding to verbal messages and other cues.
		Speaking	Communicating a thought, idea, or fact verbally in a clear, concise manner.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
Unit 5: AC and AC Circuits (cont.)			
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Determine time constants of RC circuits (J.S. 9)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
		Listening	Receiving, interpreting, and responding to verbal messages and other cues.
		Speaking	Communicating a thought, idea, or fact verbally in a clear, concise manner.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Construct a neon bulb flasher (J.S. 10)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.

Related Academic and Workplace Skills List

Unit 5: AC and AC Circuits (cont.)

Task	Skill group	Subskill	Description
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
		Listening	Receiving, interpreting, and responding to verbal messages and other cues.
		Speaking	Communicating a thought, idea, or fact verbally in a clear, concise manner.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Show the effect of capacitive reactance in AC circuits (J.S. 11)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
		Listening	Receiving, interpreting, and responding to verbal messages and other cues.
		Speaking	Communicating a thought, idea, or fact verbally in a clear, concise manner.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
	Unit 5:	**AC and AC Circuits** (cont.)	
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Determine capacitive reactance and impedance in RC circuits (J.S. 12)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
		Listening	Receiving, interpreting, and responding to verbal messages and other cues.
		Speaking	Communicating a thought, idea, or fact verbally in a clear, concise manner.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
Unit 5: AC and AC Circuits (cont.)			
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Determine resonance in a series RCL circuit (J.S. 13)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
		Listening	Receiving, interpreting, and responding to verbal messages and other cues.
		Speaking	Communicating a thought, idea, or fact verbally in a clear, concise manner.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
Determine the resonant frequency of an RCL parallel circuit (J.S. 14)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
	Unit 5: AC and AC Circuits (cont.)		
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
		Listening	Receiving, interpreting, and responding to verbal messages and other cues.
		Speaking	Communicating a thought, idea, or fact verbally in a clear, concise manner.
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Technology		Choosing procedures, tools, or equipment including computers and related technologies.
			Demonstrating proper procedures for setting up and operating equipment.
Troubleshoot AC circuits (J.S. 15)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
		Writing	Communicating a thought, idea, or fact in written form in a clear, concise manner.
		Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
		Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
		Listening	Receiving, interpreting, and responding to verbal messages and other cues.
		Speaking	Communicating a thought, idea, or fact verbally in a clear, concise manner.
	Thinking skills	Creative thinking	Using imagination to generate new ideas.
		Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Description
	Unit 5:	**AC and AC Circuits** (cont.)	
		Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
		Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
	Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
		Self-esteem	Developing self-confidence and maintaining a positive view of self.
		Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.
	Resources	Time	Selecting relevant, goal-oriented activities, ranking them in order of importance, allocating time, and understanding, preparing, and following schedules.
		Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
		Interpretation	Selecting and analyzing information and communicating the results to others.
	Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
		Application	Demonstrating proper procedures for setting up and operating equipment.
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment, including computers and other technologies.

Correlation to Electronics Industries Foundation Skills List

Note: The Electronic Industries Foundation and its parent organization, the Electronic Industries Association, have coordinated the development of a skills list for the entry-level electronics technicians. The skills are defined in *Measurement Criteria for Entry-Level Electronics Technician Skills,* a supplement to the skills standard publication *Raising the Standard—Electronics Technician Skills for Today and Tomorrow.* Skills are defined in five areas: additional skills (communications, electromechanics, LASER applications), desirable behavior and work habits, basic and practical skills (reading, math, physics, technical literacy, etc.), test equipment and tools skills, and technical skills. In recognition of the relevance of this extensive task analysis, MAVCC has attempted to address all of the EIA/EIF technical skills in the development of the *General Electronics Technician Series.* The following table lists the EIA/EIF technical skills as of the time of publication and shows at least one example of how that skill is addressed in these instructional materials. This correlation represents the opinions of the development team in interpreting the EIA/EIF skills and is not intended to imply agreement or endorsement by the Electronic Industries Foundation. Instructors and administrators wanting more information about the EIA/EIF skills list may contact the foundation directly at the following address:

919 18th Street, NW, Suite 900
Washington, DC 20006

Note: This table lists all three books in the *General Electronics Technician* series, but users should check the corresponding tables in the specific volumes for the latest information as the exact correlation with objectives may change with revisions to individual books.

Skill Code	**Skill Description**	**Applicable Publication**	**Unit Number**	**Objective(s)**
A.01	Demonstrate an understanding of proper safety techniques for all types of circuits and components	Basic	2	23-38
A.02	Demonstrate an understanding of and comply with relevant OSHA safety standards	Basic	2	27-28, 36-38
A.03	Demonstrate an understanding of proper troubleshooting techniques	Basic	3	21, 23
A.04	Demonstrate an understanding of basic assembly skills using hand and power tools	Basic	3	24-38
A.05	Demonstrate an understanding of acceptable soldering/desoldering techniques, including through-hole and surface mount devices	Basic	3	31, 33, 37-42
A.06	Demonstrate an understanding of proper solderless connections	Basic	3	6, 7, 26-29, 32

Correlation to Electronics Industries Foundation Skills List

A 07	Demonstrate an understanding of the use of data books and cross reference/technical manuals to specify and requisition electronic components	Basic	3	22
		Semiconductors	1	49
			2	53
A 08	Demonstrate an understanding of the interpretation and creation of electronic schematics, technical drawings and flow diagrams	Basic	1	16, 30, 37, 53
A 09	Demonstrate an understanding of design curves, table, graphs, and recording of data	Semiconductors	1	52, 58, 66
A 10	Demonstrate an understanding of color codes and other component descriptors	Basic	4	18, 19, 32
		Semiconductors	1	4
A 11	Demonstrate an understanding of site electrical and environmental survey	Basic	2	Supplements 12 and 13
A 12	Demonstrate the use of listening skills or assistive devices to assess signs and symptoms of malfunctions	Basic	3	21, 23
B 01	Demonstrate an understanding of sources of electricity in DC circuits	Basic	1	6
B 02	Demonstrate an understanding of principles and operation of batteries	Basic	4	5, 54
B 03	Demonstrate an understanding of the meaning of and relationships among and between voltage, current resistance and power in DC	Basic	1	7, 8
			4	32-46, 48-53
B 04	Demonstrate an understanding of the measurement of resistance of conductors and insulators and the computation of conductance	Basic	1	5, 46
			3	5
B 05	Demonstrate an understanding of application of Ohm's Law to series, parallel and series-parallel circuits	Basic	1	9
B 06	Demonstrate an understanding of magnetic properties of circuits and devices	Basic	1	38-44
B 07	Demonstrate an understanding of the physical, electrical characteristics of capacitors and inductors	Basic	5	18-45
B 08	Understand principles and operations of DC series circuits	Basic	1	18, 19
			4	32-36
B 09	Fabricate and demonstrate DC series circuits	Basic	2	47
			4	47, 28
B 10	Troubleshoot and repair DC series circuits	Basic	4	65
B 11	Understand principles and operations of DC parallel circuits	Basic	1	20, 21
			4	38-40
B 12	Fabricate and demonstrate the DC parallel circuits	Basic	2	47
B 13	Troubleshoot and repair parallel circuits	Basic	4	66
B 14	Understand the principles and operations of DC series-parallel and bridge circuits	Basic	1	22, 23
			4	30, 31, 41-45
B 15	Fabricate and demonstrate DC series-parallel and bridge circuits	Basic	4	50-52

Correlation to Electronics Industries Foundation Skills List

B.16	Troubleshoot and repair series-parallel and bridge circuits	Basic	4	64
B.17	Understand the principles and operations of Wheatstone Bridge	Basic	4	29, 30, 52
B.18	Understand the principles and operations of DC voltage divider circuits (loaded and unloaded)	Basic	4	27, 28
B.19	Fabricate and demonstrate the DC voltage divider circuits (loaded and unloaded)	Basic	4	49
B.20	Troubleshoot and repair DC voltage divider circuits (loaded and unloaded)	Basic	4	64
B.21	Understand principles and operations of DC RC and RL circuits	Basic	4	19-30
B.22	Fabricate and demonstrate DC RC and RL circuits	Basic	5	81, 84
B.23	Troubleshoot and repair DC RC and RL circuits	Basic	4	64
B.24	Demonstrate an understanding of measurement of power in DC circuits	Basic	4	37, 40, 45
C.01	Demonstrate an understanding of sources of electricity in AC circuits	Basic	1 5	6 8-12
C.02	Demonstrate an understanding of the properties of an AC signal	Basic	5	4-6
C.03	Demonstrate an understanding of the principles of operation and characteristics of sinusoidal and non-sinusoidal wave forms	Basic	5	5
C.04	Demonstrate an understanding of basic motor/generator theory and operation	Basic	5	12, 13
C.05	Demonstrate an understanding of measurement of power in AC circuits	Basic	5	56, 74
C.06	Demonstrate an understanding of the principle and operation of various power conditioning: (isolation transformers, surge suppressors, uninterruptable power systems)	Basic	5	47, 48
C.07	Demonstrate an understanding of the principle and operation of safety grounding systems: (lightning arresters, ground fault interrupters, etc.)	Basic	1	14-16
C.08	Understand principles and operations of AC capacitive circuits	Basic	5	27-41, 64-68
C.09	Fabricate and demonstrate AC capacitive circuits	Basic	5	84, 87
C.10	Troubleshoot and repair AC capacitive circuits	Basic	5	90
C.11	Understand principles and operations of AC inductive circuits	Basic	5	18-26, 59-63
C.12	Fabricate and demonstrate AC inductive circuits	Basic	5	80, 81

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C 13	Troubleshoot and repair AC inductive circuits	Basic	5	90
C 14	Understand principles and operations of AC circuits using transformers	Basic	5	14-17, 74, 75
C 15	Demonstrate an understanding of impedance matching theory	Basic	5	53
C 16	Fabricate and demonstrate AC circuits using transformers	Basic	5	78, 79
C 17	Troubleshoot and repair AC circuits using transformers	Basic	5	90
C 18	Understand principles and operations of AC differentiator and integrator circuits (determine RC and RL time constants)	Basic	5	49, 66
C 19	Fabricate and demonstrate the operation of differentiators and integrators	Basic	5	34-40
C 20	Troubleshoot and repair AC differentiator and integrator circuits	Basic	5	90
C 21	Understand principles and operations of AC series and parallel resonant circuits	Basic	5	43, 45, 62, 73
C 22	Fabricate and demonstrate AC series and parallel resonant circuits	Basic	5	88, 89
C 23	Troubleshoot and repair AC series and parallel resonant circuits	Basic	5	90
C 24	Understand principles and operations of AC RC, RL, and RLC circuits	Basic	5	24-45, 59-73
C 25	Fabricate and demonstrate AC RC, RL, and RLC circuits	Basic	5	81, 87-89
C 26	Troubleshoot and repair AC RC, RL, and RLC circuits	Basic	5	90
C 27	Understand principles and operations of AC frequency selective filter circuits	Basic	5	50-52
C 28	Fabricate and demonstrate the operation of frequency selective filter circuits	Semiconductors	2	59
C 29	Troubleshoot and repair AC frequency selective filter circuits	Basic	5	90
C 30	Understand principles and operations of AC polyphase circuits	Basic	5	16, 74, 75
C 31	Understand principles and operations of AC phase locked loop circuits	Semiconductors	2	32
C 32	Troubleshoot and repair AC phase locked loop circuits	Semiconductors	2	61
D 01	Demonstrate an understanding of the properties of semiconductor materials	Semiconductors	1	4-6
D 02	Demonstrate an understanding of PN junctions	Semiconductors	1	6

Correlation to Electronics Industries Foundation Skills List

D 03	Demonstrate an understanding of bipolar transistors	Semiconductors	1	15-27
D 04	Demonstrate an understanding of Field Effect Transistors	Semiconductors	1	28-31
D 05	Demonstrate an understanding of special diodes and transistors	Semiconductors	1	7-31, 41
D 06	Understand principles and operations of diode circuits	Semiconductors	1	9
D 07	Fabricate and demonstrate diode circuits	Semiconductors	1	58-61
D 08	Troubleshoot and repair diode circuits	Semiconductors	1	73
D 09	Understand principles and operations of optoelectronic circuits (gate isolators, interrupt sensors, infra-red sensors, etc.)	Semiconductors	2	49
D 10	Fabricate and demonstrate optoelectronic circuits	Semiconductors	1	61
D 11	Troubleshoot and repair optoelectronic circuits	Semiconductors	2	61
D 12	Understand principles and operations of single stage amplifiers	Semiconductors	1	34
D 13	Fabricate and demonstrate the operation of the single stage amplifiers	Semiconductors	1	67
D 14	Troubleshoot and repair single-stage amplifiers	Semiconductors	1	73
D 15	Understand principles and operations of thyristor circuitry	Semiconductors	1	44, 45
D 16	Fabricate and demonstrate thyristor circuitry	Semiconductors	1	60, 72
D 17	Troubleshoot and repair thyristor circuitry	Semiconductors	1	73
E 01	Understand principles and operations of multistage amplifiers	Semiconductors	1	32-40, 55
E 02	Fabricate and demonstrate the operation of multistage amplifiers	Semiconductors	1	68, 69
E 03	Troubleshoot and repair multistage amplifiers	Semiconductors	1	73
E 04	Understand principles and operations of IF circuits	Semiconductors	2	41
E 05	Fabricate and demonstrate IF circuits	See MAVCC's *Communications Electronics*		
E 06	Troubleshoot and repair IF circuits	Semiconductors	2	61
E 07	Understand principles and operations of linear power supplies and filters	Semiconductors	3	2-14
E 08	Fabricate and demonstrate linear power supplies and filters	Semiconductors	3	19-22
E 09	Troubleshoot and repair linear power supplies and filters	Semiconductors	3	15, 23
E 10	Understand principles and operations of operational amplifier circuits	Semiconductors	2	16-21

Correlation to Electronics Industries Foundation Skills List

E-11	Fabricate and demonstrate operational amplifier circuits	Semiconductors	2	54-60
E 12	Troubleshoot and repair operational amplifier circuits	Semiconductors	2	61
E 13	Understand principles and operations of audio power amplifiers	Semiconductors	1	35, 36, 39
E 14	Fabricate and demonstrate audio power amplifiers	Semiconductors	1	67-70
E 15	Troubleshoot and repair audio power amplifiers	Semiconductors	1	73
E 16	Understand principles and operations of regulated and switching power supply circuits	Semiconductors	3	2-13
E 17	Troubleshoot and repair regulated and switching power supply circuits	Semiconductors	3	23
E 18	Understand principles and operations of active filter circuits	Semiconductors	2	12-26
E 19	Troubleshoot and repair active filter circuits	Semiconductors	2	61
E 20	Understand principles and operations of sinusoidal and non-sinusoidal oscillator circuits	Semiconductors	2	27-29, 59
E 21	Troubleshoot and repair sinusoidal and non-sinusoidal oscillator circuits	Semiconductors	2	61
E 22	Understand principles and operations of fiber optic circuits using photodiodes or LASERS	Semiconductors	2	45, 46
E 23	Troubleshoot and repair fiber optic circuits using photodiodes or LASERS	Semiconductors	2	61
E 24	Understand principles and operations of RF circuits	Semiconductors	2	39, 40
E 25	Fabricate and demonstrate RF circuits	See MAVCC's *Communications Electronics*		
E 26	Troubleshoot and repair RF circuits	Semiconductors	2	61
E 27	Understand principles and operations of signal modulation systems (AM, FM, Stereo)	Semiconductors	2	42
E 28	Troubleshoot and repair signal modulation systems (AM, FM, Stereo)	Semiconductors	2	61
E 29	Demonstrate an understanding of motor phase shift control circuits	Semiconductors	2	27
E 30	Understand principles and operations of microwave circuits	Semiconductors	2	43, 44
F 01	Demonstrate an understanding of the characteristics of integrated circuit (IC) logic families	Digital	1	2
F 02	Demonstrate an understanding of minimizing logic circuits using Boolean operations	Digital	1	33
F 03	Understand principles and operations of linear integrated circuits	Semiconductors	2	2-50
F 04	Troubleshoot and repair linear integrated circuits	Semiconductors	2	61

Correlation to Electronics Industries Foundation Skills List

F 05	Understand principles and operations of types of logic gates	Digital	1	3, 4
F 06	Fabricate and demonstrate types of logic gates	Digital	1	34-38
F 07	Troubleshoot and repair types of logic gate circuits	Digital	1	46
F 08	Understand principles and operations of combinational logic circuits	Digital	1	20
F 09	Fabricate and demonstrate combinational logic circuits	Digital	1	39-45
F 10	Troubleshoot and repair combinational logic circuits	Digital	1	46
F 11	Understand principles and operations of types of flip-flop circuits	Digital	1	6, 7
F 12	Fabricate and demonstrate the operation of flip-flop circuits	Digital	1	40
F 13	Troubleshoot and repair flip-flop circuits	Digital	1	46
F 14	Understand principles and operations of types of registers and counters	Digital	1	8-11
F 15	Fabricate and demonstrate types of registers and counters	Digital	1	39, 41
F 16	Troubleshoot and repair types of registers and counters	Digital	1	46
F 17	Understand principles and operations of clock and timing circuits	Digital	1	12, 13
F 18	Fabricate and demonstrate clock and timing circuits	Digital	1	45
F 19	Troubleshoot and repair clock and timing circuits	Digital	1	46
F 20	Understand principles and operations of types of arithmetic-logic circuits	Digital	1	14
F 21	Troubleshoot and repair types of arithmetic-logic circuits	Digital	1	46
F 22	Understand principles and operations of types of multiplexer and de-multiplexer circuits	Digital	1	15, 16
F 23	Troubleshoot and repair multiplexer and de-multiplexer circuits	Digital	1	46
F 24	Understand principles and operations of types of digital to analog and analog to digital circuits	Digital	1	43, 44
F 25	Troubleshoot and repair types of digital-to-analog and analog-to-digital circuits	Digital	1	46
F 26	Understand principles and operations of types of digital display circuits	Digital	1	2, 44
F 27	Troubleshoot and repair types of digital display circuits	Digital	1	46
F 28	Understand principles and operations of power distribution and noise problems	Digital	1	19
F 29	Troubleshoot and repair power distribution and noise problems	Digital	1	46

Correlation to Electronics Industries Foundation Skills List

F 30	Understand principles and operations of types of digital encoders and decoders	Digital	1	18
F 31	Troubleshoot and repair types of digital encoders and decoders	Digital	1	46
F 32	Understand principles and operations of digital display devices	Digital	1	20, 21
F 33	Troubleshoot and repair digital display devices	Digital	1	46
G 01	Demonstrate an understanding of microprocessor interfaces	Digital	2	3
G 02	Troubleshoot and repair microprocessor interfaces	Digital	2	26
G 03	Demonstrate an understanding of essential microprocessor components	Digital	2	3
G 04	Demonstrate an understanding of microprocessor BUS concepts	Digital	2	9-12
G 05	Demonstrate an understanding of microprocessor components and terminology	Digital	2	1, 2
G 06	Understand principles and operation of types of microprocessor memory circuits	Digital	2	8
G 07	Troubleshoot and repair types of microprocessor memory circuits	Digital	2	26
G 08	Understand principles and operations of microprocessor machine code and instruction sets	Digital	2	16-18
H 01	Demonstrate an understanding of microcomputer operating systems	Digital	2	20
H 02	Demonstrate an understanding of essential microcomputer components	Digital	2	15
H 03	Demonstrate an understanding of microcomputer peripherals	Digital	2	21
H 04	Setup and configure a microcomputer using available operating systems and software packages peripherals	Digital	2	25
H 05	Troubleshoot and replace microcomputer peripherals	Digital	2	26

Introduction to Electricity and Electronics
Unit 1

Suggested Activities

Instructional Plan

Preparation

- Review unit and plan presentation. Study the specific objectives to determine the order in which you will present the objectives.

  Review the unit introduction and teaching suggestions included in the delivery and application section below, and plan classroom activities. Also note the suggestions for media and supplemental materials.

  Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.

- Obtain films, videotapes, and other media to supplement instruction of this unit. See ordering information in the suggested resources section.

- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only and should be used with objectives as indicated below.

  TM 1—Areas of Employment (Objective 2)
  TM 2—Structure of an Atom (Objective 4)
  TM 3—Movement of Electrons (Objective 4)
  TM 4—Valence Shells (Objective 5)
  TM 5—Resistance in Substances (Objective 5)
  TM 6—Crystalline Structure (Objective 5)
  TM 7—Doping Semiconductors (Objective 5)
  TM 8—Triboelectric Effect (Objective 6)
  TM 9—Electrochemical Reaction (Objective 6)
  TM 10—Electromagnetic Induction (Objective 6)
  TM 11—Photoelectric Effect (Objective 6)
  TM 12—Thermoelectric Effect (Objective 6)
  TM 13—Piezoelectric Effect (Objective 6)
  TM 14—Characteristics of Electrical Flow (Objective 7)
  TM 15 –Ohm's Law (Objective 9)
  TM 16—Watt's Law (Objective 10)
  TM 17—Types of Current (Objective 11)
  TM 18—Parts of a Simple Circuit (Objective 12)
  TM 19—Power Sources (Objective 13)
  TM 20—Circuit Structures (Objective 17)
  TM 21—Circuit Linearity (Objective 17)
  TM 22—Circuit Component Classifications (Objective 17)
  TM 23—Types of Signals (Objective 17)
  TM 24—Electrical Flow in a Series Circuit (Objective 18)
  TM 25—Electrical Flow in a Parallel Circuit (Objective 20)
  TM 26—Electrical Flow in a Series-Parallel Circuit (Objective 22)
  TM 27—Kirchhoff's First Law (Objective 24)
  TM 28—Kirchhoff's Second Law (Objective 25)
  TM 29—Maximum Power Transfer (Objective 26)
  TM 30—Superposition Theorem (Objective 27)
  TM 31—Thévenin's Theorem (Objective 28)
  TM 32—Types of Electronic Signals (Objective 33)

Suggested Activities

TM 33—Categories of Electronic Devices (Objective 34)
TM 34—Functions of Electronic Devices (Objective 35)
TM 35—Magnetic Properties (Objective 38)
TM 36—Ways of Classifying Magnets (Objective 40)
TM 37—Ways of Classifying Magnets (Continued) (Objective 40)
TM 38—Magnetic Flux (Objective 41)
TM 39—Magnetic Pole Interaction (Objective 41)
TM 40—Electromagnetism (Objective 42)
TM 41—Magnetic Induction (Objective 43)
TM 42—Electromagnetic Induction (Objective 43)

- Select teacher components (supplements, written test, unit evaluation form) you want to distribute to your students. Copy and prepare these components for distribution. The supplements included in this unit are designed for use with the objectives as indicated below.

Supplement 1 —	Explore Career Opportunities in the Electronics Industry (Objective 2)
Supplement 2 —	Obtain Circuit Components in Your Shop (Objectives 12, 29, and 36)
Supplement 3 —	Assemble and Operate a Simple Electrical Circuit (Objective 12)
Supplement 4 —	Demonstrate Ohm's Law and Watt's Law (Objectives 9 and 10)
Supplement 5 —	Construct a Simple Electromagnet and Check Its Operation (Objective 42)
Supplement 6 —	Study Types of Electronic Equipment (Objective 34)

- Prepare classroom. Put up posters and charts and display articles and other references related to the objectives of this unit.

Delivery and Application

Unit Introduction

Note: Because this is the first unit in the course, your introduction to the unit must cover a broader scope, acquainting the students with the course, competency-based education, and policies and procedures in your facility. This unit has been structured to allow you to introduce the students to the design of the instructional materials and includes all of the components used in MAVCC units of instruction except job sheets.

- Introduce the unit by displaying a variety of electronic equipment. Ask the students to discuss the roles that such equipment play in their lives on a daily basis. Expand the discussion by talking about electronics applications that the students are likely to encounter less often, such as medical equipment or air traffic control equipment or space and military applications. Use Transparency 1 to discuss the four areas of the electronics industry. Point out that this course is an excellent first step in preparing the students for careers in any of these four areas.
- Provide students with objective sheet. Point out the title and unit number and discuss the total content of your course in terms of

units of instruction, such as the five units in *Basic Electronics* or the full ten units in MAVCC's general electronics technician course. Explain that each unit of instruction is designed to present the students with some of the information that they need to know and allow them practice in the skills that they must be able to do as electronic technicians.

- Discuss unit objective. Point out that the unit objective contains two basic statements. The first tells what the student will study in this unit and, more importantly, what the student will be able to do after completing the work in this unit. The second statement explains how the student will demonstrate that he or she can do what is required to meet the objective. In this case, this ability is demonstrated by completing the assignment sheets listed with specific objectives 46-53 and the written test, which you will explain further later in this lesson.
- Discuss specific objectives. Explain how the unit objective provides a broad statement of a skill area that the electronics technician must master. Such a skill area consists of specific information that the technician must know and specific abilities that he or she must possess. This knowledge and these abilities are called competencies. The purpose of the specific objectives is to describe the competencies that will be taught in each unit of instruction. Point out that there are three types of specific objectives. Those that will be tested on the written test (such as specific objectives 1-45 in this unit) are listed first and include a verb that describes how the information will be tested.
- Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of each of these activities.

Teaching Suggestions

The skill areas appearing in bold-face type in the teaching suggestions refer to the academic and workplace skills identified in *What Work Requires of School: A SCANS Report for America 2000* and *Workplace Basics: The Skills Employers Want*. These have been adapted by MAVCC.

- Invite former students or area employers to talk to the class about career opportunities in your area and how the course will help prepare them for these opportunities. Visit companies in each of the four areas to acquaint students with the working conditions and tasks associated with each. Discuss additional educational requirements for each field, such as engineering degrees and associate degrees in electronics technology. **(Listening; speaking; decision-making; career awareness)**

Suggested Activities

- Discuss the science of electricity. Point out that electricity is just one form of energy. Explain how energy can be changed from one form to another. Emphasize applications of this principle in the operation of electronic equipment, such as converting chemical energy in a battery to provide electrical energy to power a portable compact disc player, converting the light energy of the CD laser to electricity to drive the speakers in the CD player, and converting that electricity to create mechanical vibrations in the speakers that produce sound energy. Use similar discussions to describe how other areas of science are important in electronics. Emphasize that the point of this study is not to make scientists of the students, but there are key principles that they must understand and that those are covered in this unit. **(Listening; science; applying technology)**

- Discuss variations for the symbols shown in the unit. Throughout this course, we have used *IEEE Std 315-1975* (Reaffirmed 1988), but students need to realize that they will encounter other symbols. Provide the students with clues to help them connect the symbols with the components represented. For example, point out that the loops on a transformer symbol are supposed to represent the transformer coils and the angled line of a switch symbol represents the moveable switch contact. You may want to display a disassembled switch or other components to show the inner workings that the symbols represent. **(Listening; seeing things in the mind's eye; acquiring information)**

- Ask the students whether the lights in the classroom are an electrical circuit or an electronic circuit. Ask the same question of a computer or CD player on display in the classroom. Use this approach to explain that electrical circuits are designed to use electricity as a source of power to drive lights, motors, heating coils, etc. Electronic circuits are designed to use electricity as signals. Discuss other devices and have the students classify them as electrical or electronic. For electronic devices, try to identify the signals that are used. Be sure that your discussion addresses the fact that most electronic devices use both types of circuits. For example, a calculator uses electronic inputs through the keys to address its memory circuits and electrical circuits to drive the display. A cassette player uses an electric motor to drive the tape, but electronic circuitry to read the tape and translate it into signals. **(Listening; reasoning; applying technology)**

- Use an oscilloscope to show an electronic representation of sound. Use this to discuss the other types of information that can be represented by electronic signals. **(Listening; seeing things in the mind's eye; recognizing interrelationships in technological systems)**

- When discussing the three categories of electronic devices, introduce some of the history of electronics from the development of the first gaseous-discharge tubes in the late 1800's and wide-spread commercial use of vacuum tubes in radios in the 1920's to the invention of the transistor in 1947 and increased use of discrete electronic circuits to the introduction of integrated circuits around

Suggested Activities

1960 and the continued miniaturization of microelectronics. Show current uses of all three categories of devices in a television or computer monitor. **(Listening; adapting to the organization's values and traditional modes of operation)**

Evaluation

- Discuss with students the use of the Unit Evaluation Form. Explain the rating scale that will be used for student evaluation.
- Copy written test and give to students as pretest. Record pretest score on the Unit Evaluation Form.
- Evaluate assignment sheets. See the evaluation criteria listed at the top of each assignment sheet and the component "Answers to Assignment Sheets."
- Give and evaluate written test.
- Compile written-test and assignment-sheet scores on the Unit Evaluation Form. Include any additional assignments.
- Measure competency gains by comparing written pretest scores with posttest scores.
- Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas of improvement.
- Reteach and retest as required.

Suggested Resources

Resources Used in Developing This Unit

- *Basic Electronics.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1987.
- *Communications Electronics.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1988.
- Davidson, Homer L. *Troubleshooting and Repairing Compact Disc Players.* 2nd Ed. New York, New York: TAB Books, 1994.
- *General Electronics Technician.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1987.
- *Graphic Symbols for Electrical and Electronics Diagrams.* New York: Institute of Electrical and Electronics Engineers, Inc., 1975.

Suggested Activities

- *Home Electronics.* Alexandria, Virginia: Time-Life Books, 1988.
- Roehrig, Guido and Ulrich Schueller. *Upgrading and Maintaining Your PC.* Grand Rapids, Michigan: Abacus, 1991.
- Schuler, Charles A. *Electronics Principles and Applications.* 4th edition. New York: Glencoe Division, Macmillan/McGraw-Hill School Publishing Company, 1994.
- Simpson, Colin. *Principles of DC/AC Circuits.* Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1996.

Supplemental Resources

Print Media

- *Career Discovery Encyclopedia.* J. G. Ferguson Publishing Co.: Chicago, 1990.
- *Electronic Occupational Outlook Handbook.* JIST Works: Indianapolis, 1995.
- *Encyclopedia of Careers and Vocational Guidance.* J. G. Ferguson Publishing Co.: Chicago, 1990.

Non-print Media

- *AC/DC Electronics Series.* This is an extensive series of programs released in 1986 that covers most of the topics presented in this course. Individual programs would be applicable to specific units and objectives throughout the course. Available from: Video Training Resources; 7900 W. 78th, Suite 250; Edina, MN 55429; 800-828-8190.
- *Basic Electrical Circuits.* This 1992 program discusses the atomic theory of electricity; resistors, capacitors, inductors, and transformers; as well as types of circuits. Available from: American Association for Vocational Instructional Materials; 745 Gaines School Road; Athens, GA 30605; 800-228-4689.
- *Basic Electronics: DC.* Emphasizes analog circuits and reading schematics. Available from: Bergwall Productions, Inc.; P.O. Box 238; Garden City, NY 11530-0238; 800-645-3565.
- *Basic Electronics: DC Circuits.* Covers types of circuits and resistors. Note that the program uses the term "complex circuit" for series-parallel circuits. Released in 1989. Available from: Cambrige Career Products; P.O. Box 2153, Dept. CC13; Charleston, WV 25328-2153; 800-468-4227.

Suggested Activities

- *Current Flow.* This 9-minute VHS program introduces Ohm's Law and the concepts of emf, current, and resistance. Supports Specific Objectives 4-7. Available from: International Film Bureau Incorporated, 332 S. Michigan Avenue, Chicago, IL 60604-4382. Phone (800) 432-2241.
- *DC Electronics.* A series of programs, including specific programs on circuits and devices, that is suitable for various units of instruction in this course. First releases began in 1986. Available from: Video Training Resources; 7900 W. 78th, Suite 250; Edina, MN 55429; 800-828-8190.
- *Electric Current and Magnetism.* Basic presentation about the relationship between electricity and magnetism (1991). Available from: Aims Media Inc.; 9710 DeSoto Ave.; Chatsworth, CA 91311-4409; 800-367-2467.
- *Electrical Power.* This program covers Watt's Law and other ideas in support of Specific Objective 10. Available from: International Film Bureau Incorporated.
- *Electrical Series.* A set of programs that deal with subjects ranging from basic electricity to semiconductors and, thus, is applicable to many units in this course. First released in 1992. Available from: American Association for Vocational Instructional Materials; 745 Gaines School Road; Athens, GA 30605; 800-228-4689.
- *Electricity/Electronics Series.* This group of videotapes covers most of the topics in this course and can be used throughout. Available to: Career Aids, Inc.; 20417 Nordhoff St., Dept. VCE; Chatsworth, CA; 91311.
- *Electron Flow.* Fifteen-minute color VHS program that introduces the idea of electron flow in support of Specific Objective 4. Available from: Bergwall Productions, Inc., 540 Baltimore Pike, Chadds Ford, PA 19317. Phone (800) 645-3565.
- *What is Electricity?* A 9-minute VHS program covering the fundamentals of electron flow in support of Specific Objective 4. Available from: International Film Bureau Incorporated.

Software

- *Basic Electronics.* A five-program series covering atomic theory, electronic fundamentals, electronic math, and DC circuitry. Available from: Encyclopedia Britannica Education; 425 N. Michigan Ave.; Chicago, IL 60611; (800) 554-9862.

Suggested Activities

- *Electricity Series.* This series of five-programs includes basic concepts, introduction to circuits (including meters), resistance, and exercises dealing with electrical energy such as the cost of electricity. Available from: Merlan Scientific, Ltd.; 247 Armstrong Ave.; Georgetown, Ontario L7G 46

Introduction to Electricity and Electronics
Unit 1

Answers to Assignment Sheets

Assignment Sheet 1—Apply Ohm's Law

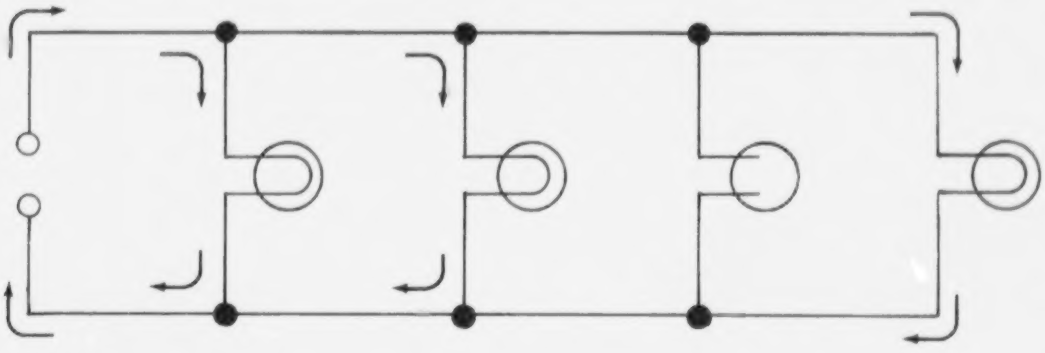
1. 120 volts
2. 20 amps
3. 60 ohms
4. 240 volts
5. 10 amps
6. 2.5 ohms
7. 24 volts
8. 22 amps
9. 2.4 ohms
10. 15 volts
11. 4 amps
12. 46 ohms
13. 12 volts
14. 8 amps
15. 3 ohms
16. 10 volts
17. 12 amps
18. 12 Kohms
19. 0.01 volts
20. 5 microamps
21. 4 Mohms
22. 8 volts
23. 0.5 amps
24. 200 Kohms
25. 4 volts
26. 4 milliamps
27. 2 Mohms
28. 1 volt
29. 2 milliamps
30. 500 Kohms
31. 44 ohms
32. 3 amps
33. 120 volts

Assignment Sheet 2—Apply Watt's Law

1. 120
2. 2880
3. 960
4. 15
5. 0.1
6. 230.4
7. 24
8. 9680
9. 60
10. 108
11. 480
12. 1150
13. 5
14. 192
15. 192
16. 20
17. 144
18. 48
19. 1
20. 0.025
21. 2
22. 64,000
23. 1
24. 5
25. 50
26. 80
27. 0.5
28. 1
29. 2
30. 12.5
31. 22.73
32. 360
33. 15

Assignment Sheet 3—Trace Current Flow in Electrical Circuits

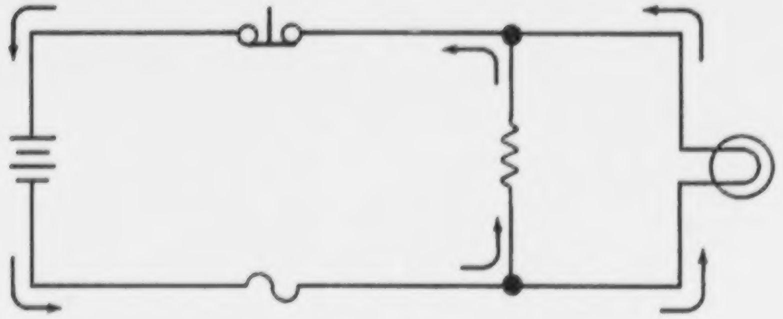
1.



2. No flow

Answers to Assignment Sheets

3.



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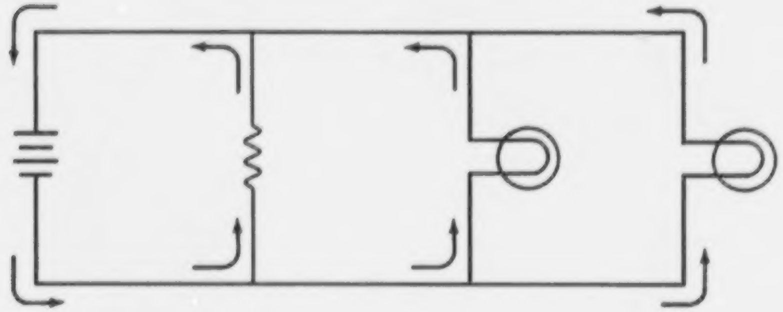

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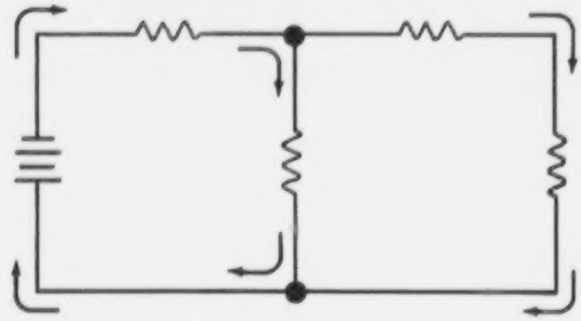

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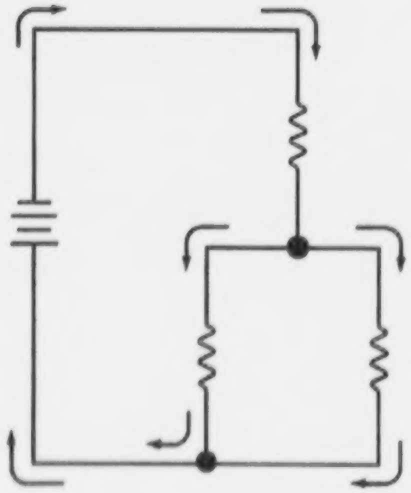

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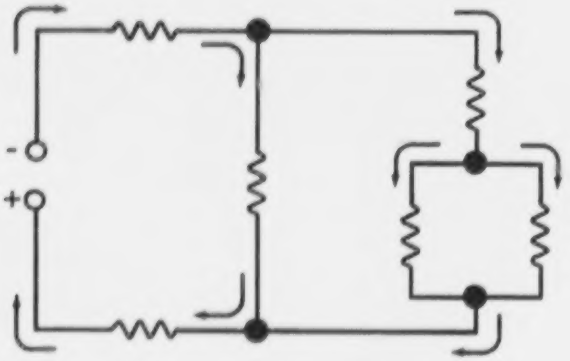

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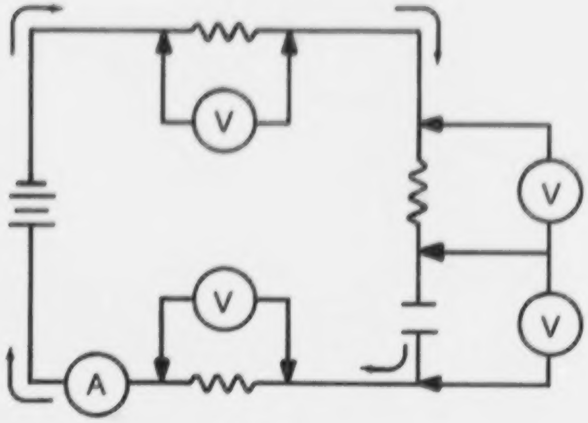
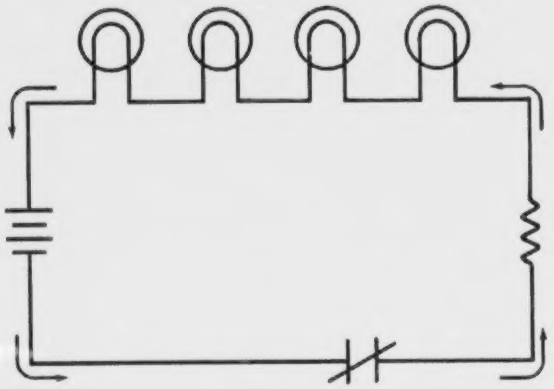
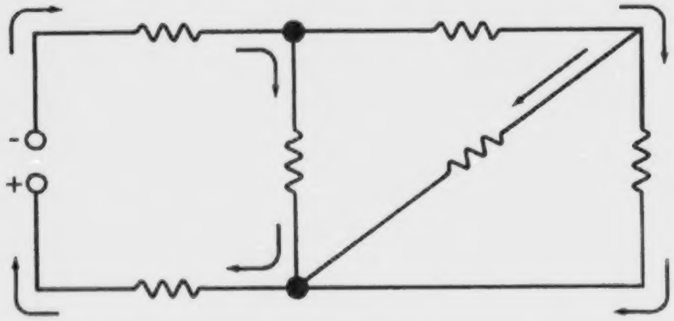


Answers to Assignment Sheets

9.



10.



Assignment Sheet 4—Apply Kirchhoff's Laws

1. 2 volts
2. 6 volts
3. 19 volts
4. 4 volts
5. 3 volts
6. 3 volts
7. 6 volts
8. 7 amps
9. 5 amps
10. a. 3.2 amps
    b. 4 amps
    c. 2.7 amps
    d. 9.9 amps
11. a. 10.7 amps
    b. 8 amps
    c. 5.3 amps
    d. 24 amps
12. a. 5 ohms
    b. 3 ohms
    c. 8 amps

Answers to Assignment Sheets

Assignment Sheet 5—Apply the Superposition Theorem

1. 3.3 amperes, 19.8 volts
2. 5.9 amperes, 23.6 volts
3. 4.2 amperes, 21.0 volts
4. 3.7 amperes, 14.8 volts
5. 2.6 amperes, 20.8 volts

Assignment Sheet 6—Apply Thévenin's Theorem

1. 1.3 amperes, 7.8 volts
2. 1.6 amperes, 6.4 volts
3. 2.4 amperes, 12.0 volts
4. 2.6 amperes, 10.4 volts
5. 0.9 amperes, 7.2 volts

Assignment Sheet 7—Convert Electrical Units of Measure

1. 410,000
2. 4.1
3. 15.3
4. 30
5. 6,700,000
6. 0.000214
7. 4.5
8. 36
9. 0.047
10. 0.0099
11. 84
12. 0.00213
13. 17,700
14. 5,500
15. 3.175
16. 250
17. 8,000,000
18. 72,500,000
19. 14,400
20. 0.00024
21. 0.12
22. 0.015
23. 23
24. 43,600,000
25. 0.0263

Assignment Sheet 8—Interpret Electrical Schematics

1. a. 510 ohms
   b. Variable DC power supply
2. a. 330 Kohms
   b. 1 Kohm
   c. Ground
   d. Operational amplifier
   e. No
3. a. 0.001 μF
   b. Inductor
   c. +12 volts
   d. Transistor
   e. AM
4. a. Transformer
   b. Diode
   c. They are adjustable.
   d. Loudspeaker
   e. 9 volt
   f. Switch (single-pole, single-throw)
   g. AC power source
   h. No
5. a. Switch (pushbutton)
   b. Transistor (photosensitive)
   c. Light-emitting diodes
   d. No
   e. Variable resistor with feedback

Introduction to Electricity and Electronics
Unit 1

Answers to Written Test

1.
   - a. 4
   - b. 3
   - c. 1
   - d. 13
   - e. 5
   - f. 8
   - g. 7
   - h. 12
   - i. 11
   - j. 10
   - k. 9
   - l. 6
   - m. 2

2.
   - a. Research and development
   - b. Manufacturing
   - c. Sales
   - d. Repair and service

3.
   - a. 5
   - b. 3
   - c. 6
   - d. 1
   - e. 4
   - f. 2

4.
   - a. matter
   - b. electrons, protons, neutrons
   - c. protons, neutrons
   - d. electrons
   - e. free
   - f. atoms
   - g. energy
   - h. electricity
   - i. conductors, insulators, semiconductors

5.
   - Conductors
     a, b, c, f
   - Insulators
     b, c, d
   - Semiconductors
     a, d, e, f, h

6.
   - a. 4
   - b. 5
   - c. 6
   - d. 3
   - e. 1
   - f. 2

7.
   - a. 1
   - b. 3
   - c. 7
   - d. 4
   - e. 6
   - f. 2
   - g. 5

8.
   - a. coulomb, C, Q
   - b. volt, V or v, E
   - c. volt, V or v, V
   - d. ampere, amp or A, I or I
   - e. ohm, ohm or Ω, R
   - f. watt, W, P
   - g. siemens, S, G

9. $E = I \times R$

Answers to Written Test

10. P = I x E

11. a. Direct current—Electrical flow in which the flow of electrons is in one direction only
    b. Alternating current—Electrical flow in which the current reverses direction periodically

12. a. Power source
    b. Switch
    c. Load
    d. Conductor

13. a. 3
    b. 1
    c. 2
    d. 4

14. To provide a drain for excess electrons

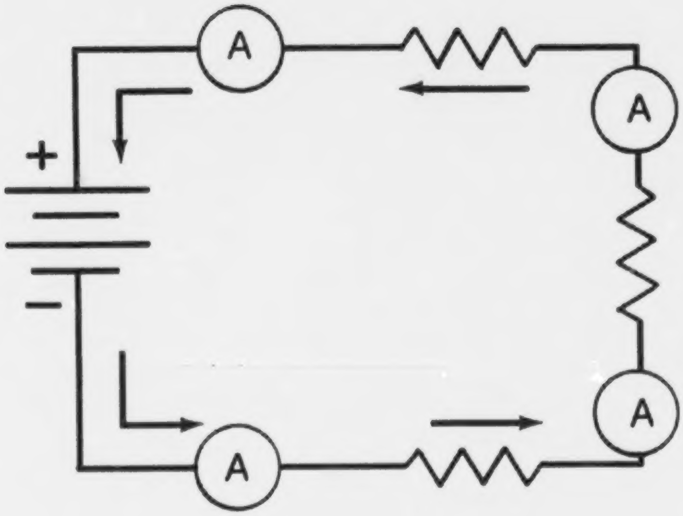
15. a. Earth—Excess electrical charge is conducted into the ground via a rod or water pipe
    b. Chassis—Excess electrical charge is conducted into metal frame of the equipment
    c. Common connections—Two or more connections are tied to one another

16. a. 2
    b. 3
    c. 1

17.
    - Structure
      a. Series
      b. Parallel
      c. Series-parallel
    - Type of current
      a. Direct current
      b. Alternating current
    - Comparison of input to output
      a. Linear
      b. Nonlinear
    - Component characteristics (answer should include three of the following)
      a. Resistive
      b. Resistive-capacitive
      c. Resistive-inductive
      d. Resistive-capacitive-inductive
      e. Inductive-capacitive
    - Type of signal
      a. Analog
      b. Digital

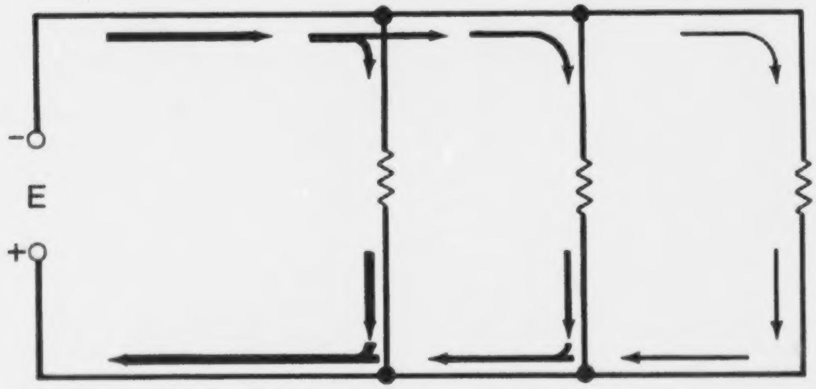
Answers to Written Test

18.



19.
- a. negative, positive
- b. applied voltage
- c. applied voltage, sum
- d. applied voltage
- e. same
- f. sum
- g. power source, sum
- h. resistance, resistance

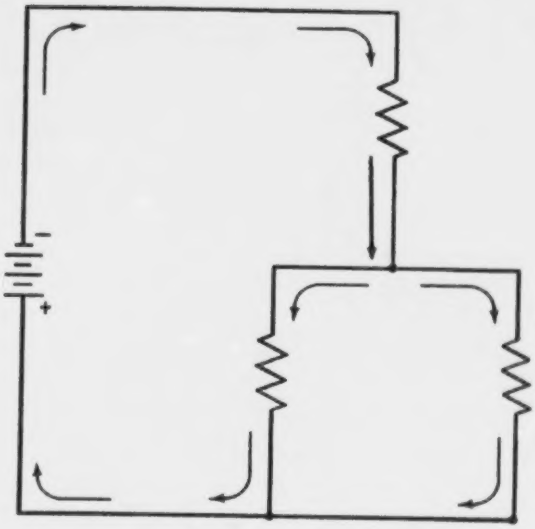
20.



21.
- a. negative, positive
- b. applied voltage
- c. applied voltage
- d. divided
- e. sum
- f. lowest
- g. reciprocal
- h. branches
- i. product, sum
- j. power source, sum
- k. resistance, resistance

Answers to Written Test

22.



23. a. series, resistance, series, parallel
    b. series, series

24. Kirchhoff's first law—The total current flowing through a parallel circuit is the sum of the currents flowing through each branch.

25. Kirchhoff's second law—The sum of the voltages around a closed loop must equal the applied voltage.

26. a. resistance, resistance
    b. efficiency
    c. high
    d. load

27. The superposition theorem—In a linear network with two or more power sources, the current or voltage for any component is the algebraic sum of the effects produced by each source acting separately.

28. Thévenin's theorem—A two terminal network of linear components and voltage sources can be replaced by an equivalent network containing one voltage source in series with one resistance.

29. • **Power sources**
    a. 2
    b. 3
    c. 4
    d. 1

Answers to Written Test

- **Conductors**
  a. 5
  b. 2
  c. 1
  d. 4
  e. 3
- **Switches**
  a. 1
  b. 5
  c. 2
  d. 7
  e. 3
  f. 4
  g. 6
- **Loads**
  a. 4
  b. 6
  c. 1
  d. 2
  e. 5
  f. 3
  g. 7
- **Protective devices**
  a. 1
  b. 2

30. a. 5
b. 10
c. 3
d. 12
e. 22
f. 18
g. 1
h. 11
i. 25
j. 9
k. 8
l. 23
m. 16
n. 4
o. 17
p. 15
q. 2
r. 19
s. 13
t. 7
u. 14
v. 20
w. 6
x. 21
y. 24

31. a. Electrical—Uses electricity to power equipment
b. Electronic—Uses electricity to produce, modify, distribute, and output signals

32. a. Sounds
b. Images
c. Symbols
d. Computer instructions
e. Measured or counted quantities

33. a. Analog signal—Represents any value within a range of values
b. Digital signal—Represents an either-or condition in that the signal is either on or off

34. a. Electron tube
b. Solid-state device
c. Integrated device

35. a. Amplification—Increasing the strength of a signal
b. Switching—Directing a signal to one or more destinations
c. Oscillation—Changing direct current into a signal of a specific pattern of vibrations
d. Energy conversion—Changing one form of energy into another

36. a. 5
b. 4
c. 3
d. 6
e. 1
f. 2

Answers to Written Test

37.

a.	2	d.	9	g.	11	j.	10
b.	6	e.	1, 8	h.	4	k.	12
c.	7	f.	3	i.	5		

38.

a.	2	d.	1
b.	3	e.	5
c.	4	f.	6

39.

a.	P
b.	F
c.	D

40. Any three of the following

- Origin
- Permanence
- Shape
- Composition

41.
a. flux
b. north pole, south pole
c. smallest
d. Like
e. Unlike

42.
a. magnetic
b. clockwise
c. current
d. coil
e. ferromagnetic

43.
a. Magnetic induction—A ferromagnetic material will become magnetized if passed through the flux field of a magnet.
b. Electromagnetic induction--Electrons can be induced to flow in a conductor if it is passed through a magnetic field.

44.
a. Strength of the magnetic field
b. Speed of conductor movement relative to the magnet
c. Angle formed between the conductor and the lines of flux
d. Amount (length) of the conductor exposed to the field

45.

a.	Giga-	G			
b.	Mega-	M			
c.	Kilo-	K			
d.	Milli-	m			
e.	Micro-	μ			
f.	Nano-	η			
g.	Micromicro-	μμ	or	Pico-	ρ

Introduction to Electricity and Electronics
Unit 1

Written Test

Name ____________________ Date __________ Score __________

1. Match terms associated with electricity and electronics to their correct definitions. Write the corresponding numbers on the blanks provided.

______a. Branch of physics that deals with the use of electricity and special devices to generate, control, distribute, and interpret signals to operate equipment or communicate information

______b. Particle thought to be found in all matter as part of the atom and to be the means by which electrical energy is generated

______c. Collection of conductors and devices designed to allow the controlled flow of electricity in order to perform work

______d. In the science of physics, the use of energy to produce movement

______e. The capacity to do work

______f. That which has weight and occupies space

______g. Statement of a scientific principle that can be demonstrated

______h. Statement of a scientific belief

______i. A mathematical formula or logical assumption based on observations that describes a relationship

______j. A written character or drawing that represents an object, characteristic, condition, or other defined aspect

______k. In mathematical relationships, the inverse of a quantity, created by dividing the quantity into 1

______l. Having the same value, effect, or function

______m. Part of a circuit designed to serve a specific purpose

1. Circuit
2. Component
3. Electron
4. Electronics
5. Energy
6. Equivalent
7. Law
8. Matter
9. Reciprocal
10. Symbol
11. Theorem
12. Theory
13. Work

Written Test

2. List the four areas of employment in the electronics industry.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

3. Match different areas of scientific study in the electronics industry to their correct descriptions. Write the corresponding numbers on the blanks provided.

______a. The study of laws and principles that govern how matter and energy behave, including magnetism, electricity, and atoms

______b. A field of physics that deals with how force affects bodies and the design and construction of machines to perform work

______c. A field of physics that deals with how gases, and particularly pressurized air, can be used to transfer force

______d. The study of the composition and structure of substances and their interaction with each other

______e. A field of physics that deals with how light behaves and how it can be used to perform work

______f. A field of physics that deals with how liquids can be used to transfer force

1. Chemistry
2. Hydraulics
3. Mechanics
4. Optics
5. Physics
6. Pneumatics

4. Complete statements concerning the electron theory of electricity. Write the missing word or words in the spaces provided.

a. All ______________ is composed of particles called *atoms*.

b. Atoms consist of smaller particles called ______________, ______________, and ______________.

c. ______________ and ______________ are grouped together in the center of the atom, called a *nucleus*.

d. ______________ go around the nucleus in circles called *orbits* or *shells*.

e. Electrons in the outer shell are called *valence electrons* and can break away from the atom and become ______________ *electrons*.

Written Test

f. Other _______________ can pick up free electrons and lose electrons from their own valence shells.

g. The flow of electrons among atoms can be increased by adding _______________ to them.

h. The flow of electrons due to increased energy constitutes _______________.

i. Substances can be classed by how easily their electrons flow; substances in which electrons flow easily are called _______________, those that resist the flow of electrons are called _______________, and those that can be made to exhibit characteristics of either conductors or insulators are called _______________.

5. Select true statements concerning the electrical characteristics of conductors, insulators, and semiconductors. Write an "X" beside each statement below that correctly describes the electrical characteristics of the type of component listed.

- Conductors

  ______a. Valence electrons separate from their atoms very easily.

  ______b. The ease with which valence electrons separate is called *conductance.*

  ______c. Conductance varies from substance to substance and with factors such as temperature, diameter of the conductor, and length of the conductor.

  ______d. The conductance of a conductor decreases as its temperature decreases.

  ______e. Because electricity is transferred by valence electrons, only solid substances can be conductors.

  ______f. Conductors, such as copper, silver, and aluminum, are used to provide electrical flow from point to point.

- Insulators

  ______a. Valence electrons are easy to separate from their atoms.

  ______b. The opposition to losing valence electrons is called *resistance.*

  ______c. Resistance varies from substance to substance and with factors such as temperature and the amount of insulator material.

  ______d. Insulators, such as rubber and plastic, are used to prevent electrical flow and can be used to wrap conductors to prevent electrical flow when other conductors contact the insulated conductor.

Written Test

______e. Insulators can be converted into conductors through a process called *doping* in which valence electrons are added to the conductor.

______f. Some insulators can store electrical charge and are called *semiconductors.*

- Semiconductors

  ______a. Semiconductors have valence shells that are filled to half their capacity with four electrons that are moderately easy to separate.

  ______b. Atoms of semiconductors, such as iron and hydrogen, can bond together so that their valence shells are filled to form *crystals.*

  ______c. Cooling a semiconductor can cause valence electrons to become free in the crystal which increases the conductance and decreases the resistance of the material.

  ______d. The conductance of a semiconductor can be improved by adding a second substance to the semiconductor that will also bond with the semiconductor valence shells; the second substance is called an *impurity* and the process of adding impurities is called *doping.*

  ______e. If the impurity has five electrons in its valence shell, such as arsenic, the impurity is called a *donor* impurity because it donates a free electron; the extra electrons give the semiconductor a negative charge and the semiconductor is called an *N-type material.*

  ______f. If the impurity has three electrons in its valence shell, such as boron, the impurity is called an *acceptor* impurity because it produces an extra hole in the valence shells of the crystal bonds; the extra holes give the semiconductor a positive charge and the semiconductor is called a *P-type material.*

  ______g. A semiconductor becomes a pure insulator when all of the P-type materials holes become filled with N-type material electrons, making electrical flow impossible.

  ______h. Electrical flow in semiconductors can occur as a flow of electrons in N-type materials or as a flow of holes in P-type materials.

6. Match sources of electricity to their correct descriptions. Write the corresponding numbers on the blanks provided.

   ______a. Production of electrical energy through the friction between two nonconducting objects moving against each other

   ______b. Production of electrical energy through exposing certain dissimilar metals to acid

   1. Thermoelectric effect
   2. Piezoelectric effect
   3. Photoelectric effect
   4. Triboelectric effect

Written Test

_____c. Production of electrical energy by moving a conductor through a magnetic field

_____d. Production of electrical energy when light strikes certain substances

_____e. Production of electrical energy by applying heat to the junction of certain dissimilar metals in contact with each other

_____f. Production of electrical energy by applying pressure to certain substances with crystalline structures

5. Electrochemical reaction
6. Electromagnetic induction

7. Match characteristics of electrical flow to their correct descriptions. Write the corresponding numbers on the blanks provided.

_____a. The condition of a material which possesses equal numbers of protons and electrons, excessive numbers of electrons, or a shortage of electrons

_____b. The pressure that pushes electrons through a material

_____c. Difference in the circuit emf as electrical energy enters a load versus the emf as electrical energy exits the load

_____d. The amount of electrons flowing past a given point in a conductor

_____e. The amount that a material opposes the flow of electricity through it

_____f. The ease with which a material supports electrical flow

_____g. The combined effect of current and electromotive force

1. Charge
2. Conductance
3. Electromotive force
4. Current
5. Power
6. Resistance
7. Voltage drop

8. Complete a chart for units of measure, their abbreviations, and symbols for characteristics of electrical flow.

	Characteristic	Unit of Measure	Abbreviation	Symbol
a.	Charge			
b.	Electromotive force			
c.	Voltage drop			
d.	Current			

Written Test

e. Resistance ____________________

f. Power ____________________

g. Conductance ____________________

9. State Ohm's Law for calculating values of given characteristics of electrical flow.

____

10. State Watt's Law for calculating power.

____

11. Describe the two forms of electrical current.

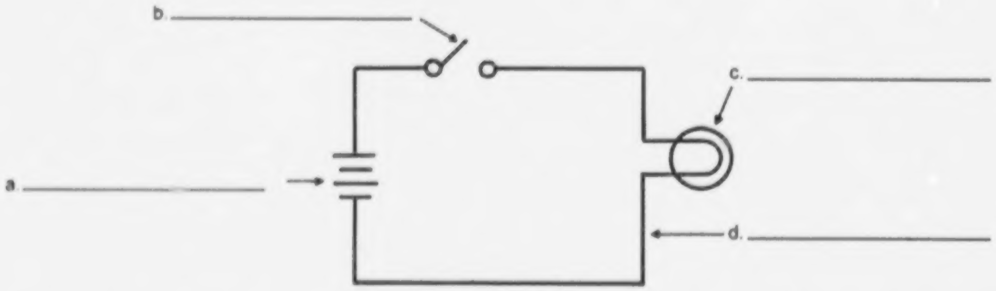
a. Direct current—____________________

____

b. Alternating current—____________________

____

12. Label the parts of a simple electrical circuit.



13. Match types of electrical circuit power sources to their correct descriptions. Write the corresponding numbers on the blanks provided.

______a. A utility company provides electricity to a facility, which uses internal wiring to route electricity to wall outlets and other junctions

______b. Device in which energy is stored in chemical form

______c. Device that uses another energy source to produce mechanical force that is converted into electricity

______d. Device that converts light into electricity

1. Battery
2. Generator
3. Service power
4. Solar cell

Written Test

14. State the purpose of the ground in an electrical circuit.

____

____

15. Describe types of grounds used with electronic equipment.

a. Earth—______________________________________

____

b. Chassis—____________________________________

____

c. Common connections—__________________________

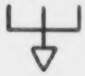
____

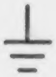
16. Match types of grounds used with electronic equipment to their correct symbols. Write the corresponding numbers on the blanks provided.

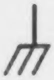
_______a. Earth

_______b. Chassis

_______c. Common connections

1. 

2. 

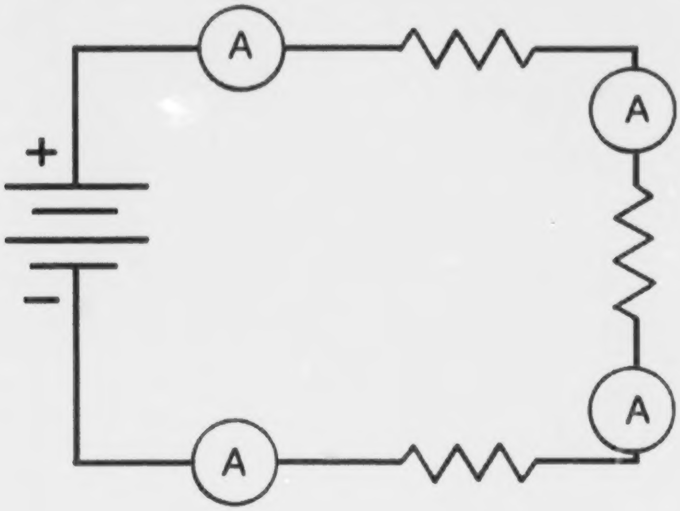
3. 

17. List classifications of electrical/electronic circuits.

- Structure
  a. ______________________________________
  b. ______________________________________
  c. ______________________________________
- Type of current
  a. ______________________________________
  b. ______________________________________

- Comparison of input to output
  a. ______________________________
  b. ______________________________
- Component characteristics (list at least three)
  a. ______________________________
  b. ______________________________
  c. ______________________________
- Type of signal
  a. ______________________________
  b. ______________________________

18. Trace the flow of electricity in a series circuit. Draw an arrow from the source of electrical flow to the point of return to the source in the diagram below. Include an arrowhead at the end of the arrow where current returns to the source.



19. Complete statements about electrical characteristics in a series circuit.

a. Charge—Electrons flow from the ______________ side of the power source to the ______________ side of the power source

b. Total electromotive force (emf)—Is the same as ______________

c. Electromotive force at any point in the circuit—Is equal to the _______________ less the _______________ of the voltage drops between the source and that point in the circuit

d. Voltage drop—The sum of all voltage drops is equal to the _______________

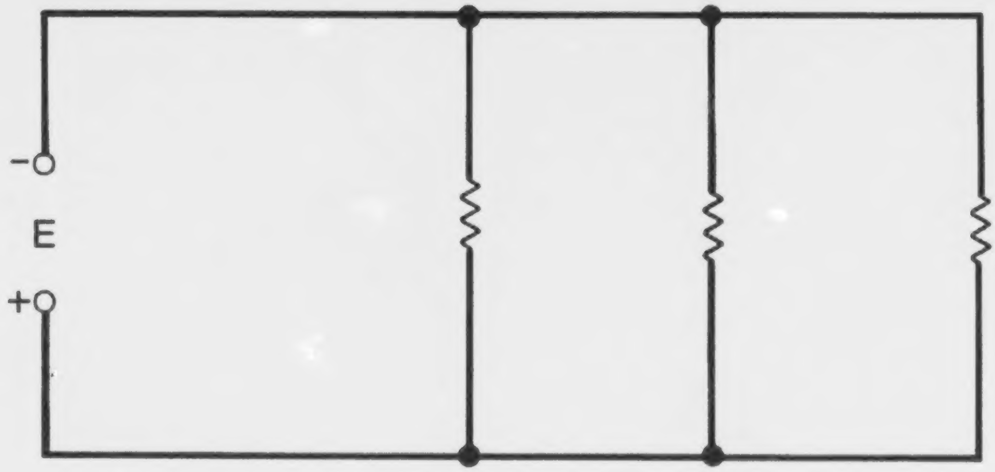
e. Current—Is the _______________ throughout the circuit as computed by Ohm's Law

f. Resistance—Total resistance equals the _______________ of the resistance values of each portion of the circuit

g. Power—Equals the power of the _______________ and is the same as the _______________ of the power across each resistance

h. Conductance—Equals the reciprocal of total _______________ with conductance across a portion of the circuit being equal to the reciprocal of the _______________ of that portion of the circuit

20. Trace the flow of electricity in a parallel circuit. Draw an arrow from the source of electrical flow to the point of return to the source in the diagram below. Include an arrowhead at the end of the arrow where current returns to the source.



Written Test

21. Complete statements about electrical characteristics in a parallel circuit.

a. Charge—Electrons flow from the _______________ side of the power source to the _______________ side of the power source

b. Electromotive force (EMF)—Is the same as _______________ at any point in the circuit

c. Voltage drop—In each parallel branch is equal to the _______________

d. Current for each branch—Is equal to the voltage _______________ by the resistance of that branch

e. Total current—Is equal to the _______________ of the currents across each branch

f. Total resistance—Is less than the _______________ resistance of any branch

g. Total resistance—Is equal to the _______________ of the sum of the reciprocals of the parallel resistances

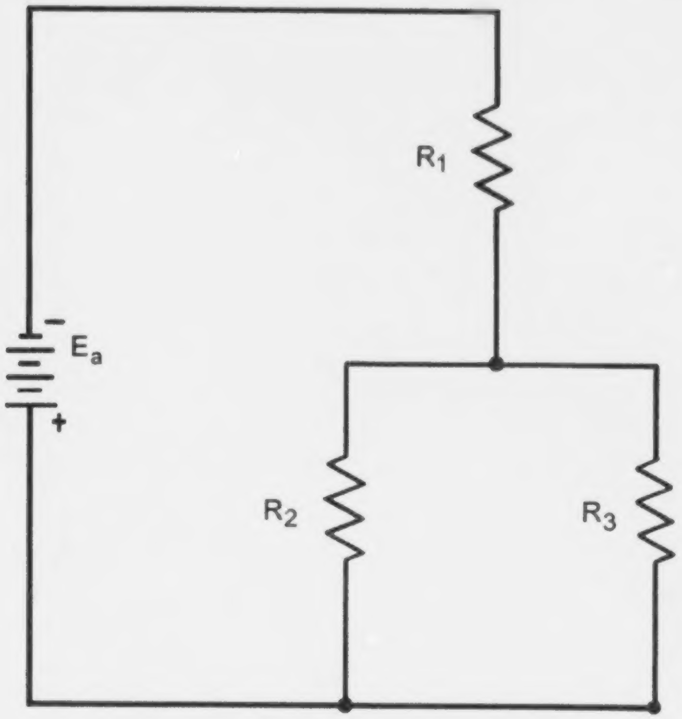
h. Total resistance if the resistance values of each branch are equal—Is equal to the branch resistance divided by the number of _______________

i. Total resistance of two parallel branches with unequal resistance values—Is equal to the _______________ of the two values divided by the _______________ of the two values

j. Power—Equals the wattage of the _______________ and is the same as the _______________ of the power of each branch

k. Conductance—Equals the reciprocal of total _______________ with conductance across a portion of the circuit being equal to the reciprocal of the _______________ of that portion of the circuit

22. Trace the flow of electricity in a series-parallel circuit. Draw an arrow from the source of electrical flow to the point of return to the source in the diagram below. Include an arrowhead at the end of the arrow where current returns to the source.



23. Complete statements about electrical characteristics in a series-parallel circuit.

   a. To determine the electrical characteristics of a series-parallel circuit, the circuit is converted to an equivalent _______________ circuit.

      - Compute the total _______________ for the parallel portion of the circuit.
      - Use the equivalent resistance to compute the resistance of a _______________ circuit.
      - Repeat these steps for other _______________ portions of the circuit until only series elements remain.

   b. Once the circuit is converted to a _______________ circuit and the resistances determined, the circuit can be treated like a _______________ circuit to determine other electrical characteristics (current, voltage, conductance, etc.)

Written Test

24. State Kirchhoff's first law regarding current in a circuit.

25. State Kirchhoff's second law regarding voltage in a circuit.

26. Complete statements about the principle of maximum power transfer. Write the missing word or phrase in the space provided or circle the correct choice given in parentheses (choice 1, choice 2).

    a. The amount of power that can be transferred from the power source to the load is governed by the ______________ of the power source and the ______________ of the load.

    b. The ______________ of power transfer is defined as the ratio of the output power to the input power.

    c. The highest power transfer efficiency occurs when the load resistance is (high, low) relative to the source resistance.

    d. Maximum power transfer occurs when the resistance of the ______________ is equal to the internal resistance of the power source.

27. State the superposition theorem.

28. State Thévenin's theorem.

Written Test

29. Match electrical components commonly used in electronic equipment to their correct descriptions. Write the corresponding numbers on the blanks provided.

- **Power Sources**

______a. Two or more cells containing a chemical called an *electrolyte* and metal rods or plates called *electrodes* that produce electricity through chemical action

______b. Circuit or device that provides a specific electrical output by converting power from another power source or from another energy source, such as converting AC to DC

______c. Device used to increase (step up) or decrease (step down) AC voltage

______d. Supply of alternating current external to the equipment, usually accessed with a power cord

1. AC source
2. Battery
3. Power supply
4. Transformer

- **Conductors**

______a. Thin, flexible, generally metal rod often coated with an insulating substance

______b. Method of packaging multiple conductors in a generally round or flat grouping with each conductor individually insulated

______c. Metal strip, usually equipped with terminals to which conductors can be attached as part of a common circuit

______d. Method of attaching a conductor to a device often through the use of threaded fasteners or clips

______e. Method of attaching a conductor to a device or for joining conductors that usually involves the mating of two parts to form a mechanical and electrical union

1. Bus
2. Cable
3. Connector
4. Terminal
5. Wire

Written Test

- **Switches**

______a. Device that is actuated electrically, mechanically, or through some other means to complete or break a circuit; usually the conducting portion of another type of switch

______b. Switch in which the circuit is completed by the movement of one connecting device

______c. Switch in which two circuits are completed by the movement of one connecting device with multiple, electrically independent contacts

______d. Switch that provides on and off positions and sometimes additional positions, usually through the actuation of a lever that may lock in place or provide just momentary contact

______e. Switch that is usually actuated by depressing a button; actuation of the switch may complete or break the circuit with the actuating button reset by a spring or other mechanism

______f. Switch that generally allows adjustment of a current or analog signal across a range by rotation of the switch; the device may have infinite adjustment across the range or may have step positions across the range that are often notch or *detent* positions for the switch

______g. Switch that moves back and forth along a path in a single plane; the device may serve one circuit and allow adjustment of that circuit or it may complete or break different circuits in various positions

1. Contact
2. Double-throw, double pole switch
3. Pushbutton
4. Rotary
5. Single-throw, single-pole switch
6. Slide
7. Toggle switch

Written Test

- **Loads**

______a. Device that converts electrical energy into light

______b. Device that converts electrical energy into vibrations that duplicate recorded or live sound

______c. Device that converts electrical energy into movement of a hammer to strike a metal dome to produce a ringing sound

______d. Device that converts electrical energy into a vibration that produces a low humming sound

______e. Device that converts electrical energy into rotary motion to allow work to be done

______f. Device that provides a specific amount of opposition to the flow of current through it

______g. Device that opposes the flow of current through it that can be adjusted to change the amount of opposition

1. Bell
2. Buzzer
3. Fixed resistor
4. Lamp
5. Motor
6. Speaker
7. Variable resistor

- **Protective devices**

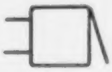
______a. Resettable device designed to open a circuit in the event of a potentially dangerous condition, such as overcurrent or high temperatures

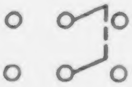
______b. Nonresettable device designed to open a circuit in the event of a potentially dangerous condition, such as overcurrent or high temperatures

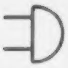
1. Circuit breaker
2. Fuse

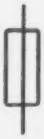
Written Test

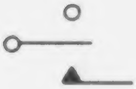
30. Match electrical components commonly used in electronic equipment to their correct symbols. Write the corresponding numbers on the blanks provided.

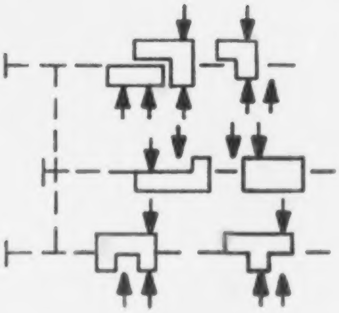
______a.


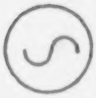
______b.


______c.


______d.


______e.


______f.


______g.


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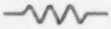
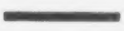
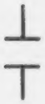


______i.


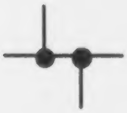
1. AC source
2. Battery
3. Bell
4. Bus
5. Buzzer
6. Cable
7. Circuit breaker
8. Intersection with connection
9. Contact
10. Double-throw, double-pole switch
11. Fixed resistor
12. Fuse
13. Lamp
14. Motor
15. Power supply
16. Pushbutton
17. Rotary switch
18. Slide switch
19. Single-throw, single-pole switch
20. Speaker
21. Terminal
22. Toggle switch
23. Transformer
24. Variable resistor
25. Wire (conductor)

Written Test

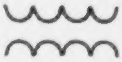
______j.



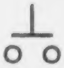
______k.



______l.



______m.



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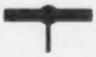
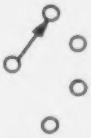
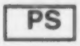


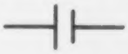
______o.



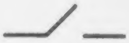
______p.



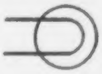
______q.



______r.



______s.



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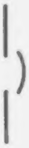
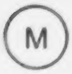
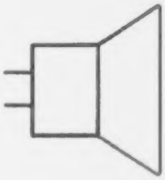


______u.

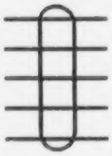


______v.

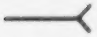


Written Test

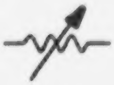
______w.



______x.



______y.



31. Describe the difference in purposes between electrical circuits and electronic circuits.

   a. Electrical—______________________________

   ____

   b. Electronic—______________________________

   ____

32. List types of information that can be represented by electronic signals.

   a. ______________________________
   b. ______________________________
   c. ______________________________
   d. ______________________________
   e. ______________________________

33. Describe the two types of electronic signals.

   a. Analog—______________________________

   ____

   b. Digital—______________________________

   ____

34. List the three categories of electronic devices.

   a. ______________________________
   b. ______________________________
   c. ______________________________

Written Test

35. Describe the four main functions of electronic devices.

    a. Amplification—____

    ____

    b. Switching—____

    ____

    c. Oscillation—____

    ____

    d. Energy conversion—____

    ____

36. Match electronic devices to their correct functions. Write the corresponding numbers on the blanks provided.

______a. Provides control functions through the use of one or more internal diodes

______b. Amplifies and shifts the signal pattern of its output compared to its input

______c. Allows electrical current flow in one direction only

______d. Amplifies or controls signals as a device that comes in various packages generally having three terminals

______e. Increases the strength of a signal

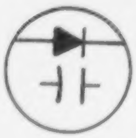
______f. Stores electrical charge

1. Amplifier
2. Capacitor
3. Diode
4. Operational amplifier
5. Thyristor
6. Transistor

37. Match electronic devices to their correct symbols. Write the corresponding numbers on the blanks provided.

Note: A symbol may have more than one correct answer.

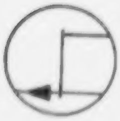
______a.



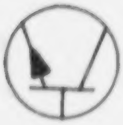
1. Amplifier
2. Capacitive diode

Written Test

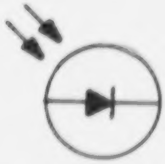
______b.



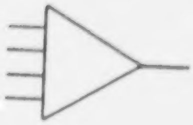
______c.



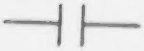
______d.



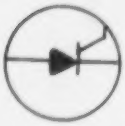
______e.



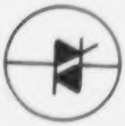
______f.



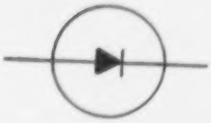
______g.



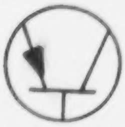
______h.



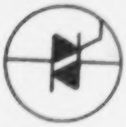
______i.



______j.



______k.



3. Capacitor
4. Diac
5. Diode
6. Field-effect transistor
7. NPN-type transistor
8. Operational amplifier
9. Photo-sensitive transistor
10. PNP-type transistor
11. Silicon-controlled rectifier
12. Triac

38. Match magnetic properties to their correct descriptions. Write the corresponding numbers on the blanks provided.

______a. Field of magnetic force that surrounds a magnet; represented by the Greek letter phi (ϕ)

______b. Measure of the force of a magnet as indicated by the number of lines of flux that pass through a given area; represented by the letter B

______c. Amount of force that produces flux around an electromagnet or coil; measured in ampere-turns and abbreviated mmf

______d. Flux density around an electromagnet that is a product of the mmf and the length of the coil; measured in ampere-turns/inch and represented by the letter H

______e. Ease with which a substance concentrates the lines of magnetic force; represented by the Greek letter mu (μ)

______f. Opposition to flux; it is the reciprocal of permeability and is represented by the letter R

1. Field intensity
2. Flux
3. Flux density
4. Magnetomotive force
5. Permeability
6. Reluctance

39. Classify substances based on their magnetic characteristics. Write an "F" beside the substances described below that are ferromagnetic, a "P" beside those that are paramagnetic, and a "D" beside those that are diamagnetic.

______a. Substances that are only slightly attracted by magnetic fields

______b. Substances that are readily attracted by magnetic fields

______c. Substances that are slightly repelled by magnetic fields

40. List ways of classifying magnets.

a. ______________________________

b. ______________________________

c. ______________________________

Written Test

41. Complete statements about magnetic flux lines.

    a. The force around magnets takes the form of lines of ______________.

    b. The force flows from one part of the magnet (termed the ______________), into the space around the magnet, and back to the magnet at a second point (termed the ______________) to form loops around the magnet.

    c. Flux lines do not cross each other and tend to restrict themselves to the ______________ possible loops.

    d. ______________ poles repel each other.

    e. ______________ poles attract each other.

42. Complete statements about electromagnetism.

    a. When electricity flows through a conductor, a ______________ field is formed around the conductor.

    b. The flow of the field is ______________ as viewed from the negative end of the conductor.

    c. The stronger the electrical ______________, the stronger the magnetic field.

    d. The magnetic field can be strengthened by winding the conductor into a ______________.

    e. The magnetic field can be increased even more by placing a ______________ rod through the loops of the coil.

43. Describe induction.

    a. Magnetic induction—______________________________

    b. ______________________________

    c. Electromagnetic induction—______________________________

    ____

44. List factors that influence the amount of current produced through induction.

    a. ______________________________

    b. ______________________________

    c. ______________________________

    d. ______________________________

Written Test

45. State prefixes and symbols used with electrical and electronic terms to show decimal and powers of ten values.

	Prefix	Symbol	Decimal Multiplier	Factor of 10
a.	________	_____	1,000,000,000.	10^9
b.	________	_____	1,000,000.	10^6
c.	________	_____	1,000.	10^3
d.	________	_____	0.001	10^{-3}
e.	________	_____	0.000001	10^{-6}
f.	________	_____	0.000000001	10^{-9}
g.	________	_____	0.000000000001	10^{-12}
	or			
	________	_____		

*Permission to duplicate this test is granted.

Introduction to Electricity and Electronics
Unit 1

Unit Evaluation Form

Student Name ______________________________ Unit Rating ______________

Assignment Sheet Ratings

Assignment Sheet 1--Apply Ohm's Law Rating _____

Comments: ____

____

Assignment Sheet 2—Apply Watt's Law Rating _____

Comments: ____

____

Assignment Sheet 3—Trace Current Flow in Electrical Circuits Rating _____

Comments: ____

____

Assignment Sheet 4—Apply Kirchhoff's Laws Rating _____

Comments: ____

____

Assignment Sheet 5—Apply the Superposition Theorem Rating _____

Comments: ____

____

Assignment Sheet 6—Apply Thévenin's Theorem Rating _____

Comments: ____

____

Assignment Sheet 7—Convert Electrical Units of Measure Rating _____

Comments: ____

____

Assignment Sheet 8—Interpret Electrical Schematics Rating _____

Comments: ____

____

Unit Evaluation Form

Written-Test Scores

Pretest _______ Posttest _______ Other _______

Other ____

____

Teacher Signature ______________________________ Date ______________

Student Signature ______________________________ Date ______________

***Permission to duplicate this form is granted.**

Introduction to Electricity and Electronics
Unit 1

Supplement 1--Explore Career Opportunities in the Electronics Industry

Introduction

This course has been designed to support instruction of students with varied backgrounds. Some classes may be composed of high school students who are just beginning to enter the workforce. Some of them may be seeking training to allow them to get an entry-level position in electronics while others may view the course as preparation for higher education courses in engineering and related fields.

Some classes may consist of adult students who either want to change career fields into electronics or who are already working in the electronics trade but who want to improve their skills or upgrade to a more technical position. Some adults may be taking the course as hobbyists who simply want to learn to service the many pieces of electronics that are filling their homes.

Consequently, the use of this supplement must be tailored to fit the needs of your class or of individual students. The supplement is designed to allow students to gain more information about the responsibilities, training requirements, working conditions, and benefits of specific employment opportunities in the electronics industry.

Directions

The form on the next page lists areas for students to explore in a selected occupation. There are three primary ways for students to complete this assignment.

Research Project. The students can be asked to research occupational information available at your facility or in public libraries. The Teaching Resources section of the Suggested Activities component of this unit lists resources that can be used.

Individual Interview. Students can seek individuals who work in the selected occupation to interview. Interviews can be made over the telephone, E-mail, or through letters, especially if such resources are limited in your area.

Group Interviews. You can invite resources to your facility from various occupations to discuss their work. This may be done to support your class or as part of a career-day type activity. Group interviews are also possible through teleconferencing and videoconferencing.

Once the students have obtained the information, you may want to share their reports with other students by having individuals or groups of students make oral reports about their findings or by assembling a collection of the reports in a notebook that is available for the class to review. The notebook approach allows reports to be grouped by occupation.

Supplement 1

Electronics Occupation Survey

Survey completed by ______________________________ Date ____________

Occupation ____

Industry Area:

____ Research and Development

____ Manufacturing

____ Sales

____ Repair and service

General responsibilities ____

____

____

Career progression ____

____

Training Requirements

Entry-level ____

Continuing ____

Work environment ____

____

Salary expectations:

Entry-level ____________

After 5 yrs ____________

Employment outlook:

Approx. annual openings ______________

Current supply vs. demand ______________

Future supply vs. demand ______________

Employment opportunities in this geographical region ____________________________

____

***Permission to duplicate this form is granted.**

Introduction to Electricity and Electronics
Unit 1

Supplement 2--Obtain Circuit Components in Your Shop

Introduction This exercise serves several purposes. First, your students are probably eager to get into the shop but are not prepared to do much due to their limited knowledge of safety and tools, which are covered in the next unit. While you will probably want to give the class a tour of the facilities, such walk-throughs have limited impact unless reinforced with more in-depth activities such as the one in this supplement.

Second, this exercise acquaints students with the procedures used in your facility for issuing parts. If you use students to staff a parts counter, it gives you the opportunity to discuss those policies and to begin preliminary scheduling of student assistants. It gives you the opportunity to emphasize areas such as safety, ESD protection, inventory control, administrative procedures, etc. early in the course so that students immediately understand your position in these areas.

Finally, the exercise introduces students to the concept of electrical and electronic components and that there are specific devices to perform particular functions. You can use this opportunity to introduce students to bills of materials and parts lists used in your facility.

Directions Use this supplement in conjunction with Supplements 3 through 6 to collect the materials needed to do the demonstrations described in those supplements. Depending on the qualifications of your students, you may simply demonstrate pulling parts to fill an order or in response to a bill of materials or you may allow students to pull the parts as individuals or in small groups. You may even be able to progress from demonstration to student participation as you go through the supplements.

Create a parts list, bill of materials, or order form (per your facility procedures) for each supplement and use it to obtain the parts to support the demonstrations.

Supplement 3--Assemble and Operate a Simple Electrical Circuit

Introduction This supplement can be used to assemble an electrical circuit so that you can demonstrate its operation or you can issue parts kits and allow the students to assemble and operate circuits as individuals or in small groups.

Once the circuit is operational, use it to demonstrate various principles, such as control of the circuit with a switch, what happens if a conductor is broken or shorted, etc. This circuit can also be used to do the demonstrations in Supplement 4 and to construct the electromagnet in Supplement 5.

Directions Suggested materials for the circuit include:

- Plywood, pegboard, or breadboard approximately 12" x 18"
- 9-volt battery
- 3 feet of single-conductor insulated 16-gauge wire
- Switch, either single-pole, single-throw or pushbutton (depending on load selection)
- Load, either a buzzer or a low-voltage lamp and socket
- Hardware to support installation method

Your choice of loads may depend on how you want to do the demonstration. The buzzer has the advantage of being easily observed when operating, whereas a low voltage lamp may be difficult to see in a normally lighted classroom if you choose to demonstrate the circuit to the class. The disadvantage of the buzzer is that the noise can be distracting if you choose to let individual or small groups of students do this demonstration. Similarly, the use of a pushbutton with the buzzer provides a quickly responsive switch and is a realistic choice for a buzzer circuit, though the throw switch probably provides a better demonstration of opening and closing a circuit.

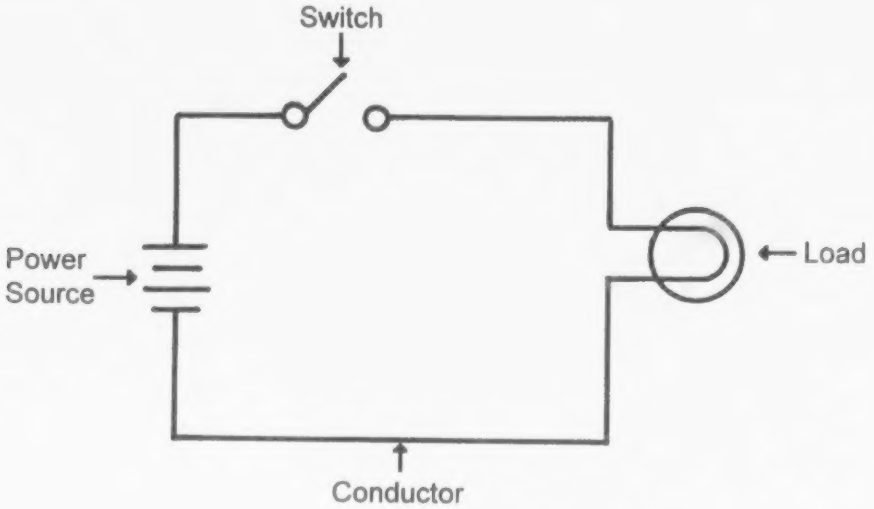
Wire the circuit as shown in Figure 1 on the next page. If you are preparing the display for your use to demonstrate a circuit, you will probably want to construct it so that it can be operated while vertical, providing a holder or cut-out for the battery and adding props or making the display so that it can be set on an easel.

If you choose to let the students construct the circuit, you will need to simplify the project as much as possible because of their limited knowledge of tools and materials and lack of safety training. For example, you may want to cut the wire to length and strip the ends. You may want to use switches and loads with pressure connectors to allow easy wire installation. You may even want to prepare the boards to the point that all the students have to do is install the battery and add the conductors. While this requires more preparation on your part, you must consider the fact that this can be a good motivational exercise for students who are eager to do some hands-on activities early in the course. Additionally, once the circuits have been prepared, they can be saved for use with other classes.

Supplement 3

Whether assembled by you or the students, relate the circuit to the parts of a circuit discussed in Objective 12. Use the circuit as an example of common ground in Objective 14 and to trace electrical flow in a simple circuit in Objective 18.

FIGURE 1



Supplement 4--Demonstrate Ohm's Law and Watt's Law

Introduction Teaching Ohm's Law presents three basic obstacles for an instructor. First, it introduces concepts that will be completely new to most students. Secondly, because the law represents a mathematical relationship, students who are weak in math or adverse to the subject may have special problems understanding the relationships. Finally, many students--especially adolescents--want to be offered "proof" of theoretical concepts. This demonstration will allow you to reinforce the concepts of Ohm's Law and make it more concrete for those who have difficulty with mathematical concepts or who require proof.

Directions Use the simple circuit constructed in Supplement 3 or a similar circuit and a multimeter to make the required measurements as outlined in the steps below.

1. Begin by relating the circuit components to the characteristics described by Ohm's Law. For example, the battery or other power source provides a measurable voltage output, the circuit provides a measurable resistance, and current can be measured.
2. Measure the output of the power source and relate this to applied voltage.
3. Hook up the power source and measure voltage drops at key points in the circuit.
4. Measure resistance at key points in the circuit.
5. Measure current at key points in the circuit.
6. Use Ohm's Law to show how the measurements you have obtained are consistent with the principle.
7. Substitute other loads, such as adding resistors of known values, to show the impact of such changes.

Note: During the demonstration, show that readings cannot be obtained on insulation. Repeat the demonstration with measurements of current and voltage to demonstrate Watt's Law. By substituting lamps of various amperage ratings and varying the power output of the circuit, you can show how circuit power affects the ability of the circuit to do work. By adding batteries and loads in series, you can also use this circuit to demonstrate Kirchhoff's Laws.

Introduction to Electricity and Electronics
Unit 1

Supplement 5--Construct a Simple Electromagnet and Check Its Operation

Introduction You will probably want to use permanent magnets to demonstrate flux lines (using a piece of paper and metal filings) and principles such as the attraction and repulsion between poles. However, the objectives dealing with induction and electromagnetism are better supported through the construction of a simple electromagnet. Kits for building electromagnets are available at many electronic and hobbyist stores, and plans for such circuits are presented in many resources. This supplement contains a design for an electromagnet and information about how to use it to support this unit of instruction.

Directions This electromagnetic circuit can be constructed independently or as a modification to the series circuit shown in Supplement 3. Depending on which approach you use, you will require some or all of the following suggested materials.

- Plywood, pegboard, or breadboard approximately 12" x 18"
- 9-volt battery
- 3 feet of single-conductor insulated 16-gauge wire
- Switch, either single-pole, single-throw or pushbutton (depending on load selection)
- Terminals to attach coils

  Note: If using the circuit from Supplement 3, construct the original circuit so that the lamp can be removed and replaced with coils for the electromagnet.
- Hardware to support installation method
- Several coils made of 16-gauge wire
- An iron rod that can be slid into the coils
- Metallic objects of various sizes and weights to be attracted by the electromagnet

1. Install the smallest coil into the circuit with the switch open. Show that it does not exhibit magnetism by attempting to pick up some metallic objects.
2. Close the switch and show that the coil now generates a magnetic field and that it will pick up some of the objects but not others. At this point, you may choose to demonstrate that increasing the current will increase the intensity of the magnetic field by installing a larger power source.
3. Replace the coil with a coil having more windings. Using the same power source as in the original demonstration, show that increasing the number of coils increases the strength of the magnetic field. You may have to experiment with the numbers of coils used or with the objects used in your demonstration, but you should be able to set up conditions in which the first coil will pick up some small objects but not pick up larger ones. Then by increasing the number of coils, the electromagnet will pick up objects that the first coil could not.

Supplement 5

4. Pass the rod into the coil and show that the electromagnet is further strengthened. Again, with a little experimentation, you should be able to set up the demonstration so that one set of objects is picked up by the small coil, additional objects are picked up by the larger coil, and even more objects are picked up when the rod is placed within the coil field.

Discuss applications of electromagnets in the electronics industry and how these principles can be applied to achieve specific results in equipment operation.

Introduction to Electricity and Electronics
Unit 1

Supplement 6--Study Types of Electronic Equipment

Introduction This supplement will allow your students to pull together much of what they have learned in this unit and to wrap up their introduction to the electronics industry. The form on the next page will be used to allow them to study specific electronic devices and relate those devices to information in this unit of instruction.

Directions Provide the students with a copy of the form on the next page. Discuss the form with the students and help them to see how the information to be collected relates to what they have studied (or will study) in the unit. For example, one section of the form deals with the manufacture and repair of the device. This information is pertinent to the areas of employment in the electronics industry and to their career exploration and job-seeking efforts. Information about the electrical characteristics of the equipment is relevant to circuit design and Ohm's Law, as well as other unit objectives.

Help the students to understand what type of information you want with each item on the form and ways in which they may obtain that information.

Ask the students to select a piece of electronic equipment and complete the form based on that piece of equipment. The device reported on may be something that the student has in his or her home, a device in your facility, or one studied in a store, office, or another electronics facility.

The students may do the project as individuals or in small groups. If possible have them share their study with other members of the class. This can be accomplished through oral reports, creation of posters, demonstrations, videotapes, or other methods. If your program emphasizes broadcast or communications electronics, you may want to produce audio or video programs that report the study results.

Supplement 6

Report on an Electronic Device

Student Name ________________________ Date ____________

Type of Equipment ________________________________

Manufacturer ________________________ Model No. __________

Place of Manufacture ________________________________

Nearest Repair Facility ________________________________

General Purpose of Equipment ________________________________

____

Major Functional Sections of Equipment (Attach schematic if available):

____

General Electrical Design:

  Power Source(s) ________________________________

  Loads ________________________________

  Switches and Controls ________________________________

  Other ________________________________

Electrical Information:

  Wattage ________________________________

  Amperage ________________________________

Electrical and Other Hazard Warnings Provided ____________________

____

Mechanical Devices Used with Equipment (doors, drives, pulleys, belts, gears, etc.) ______

____

Other Pertinent Information ________________________________

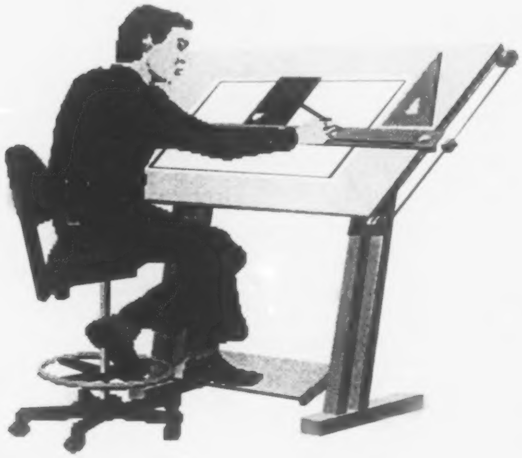
____

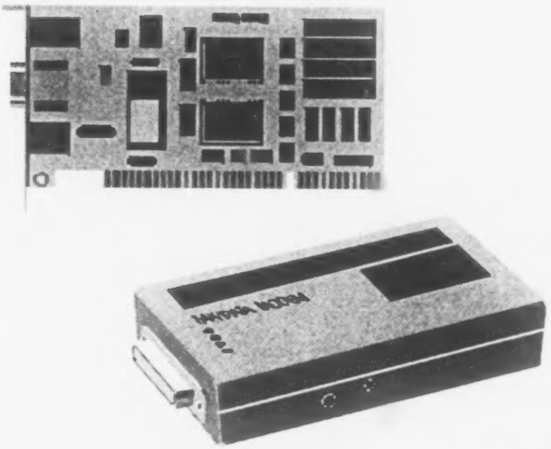
***Permission to duplicate this form is granted.**

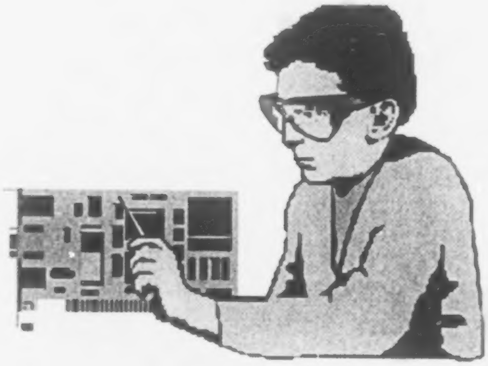
Areas of Employment

- **Research and development**

- **Manufacturing**



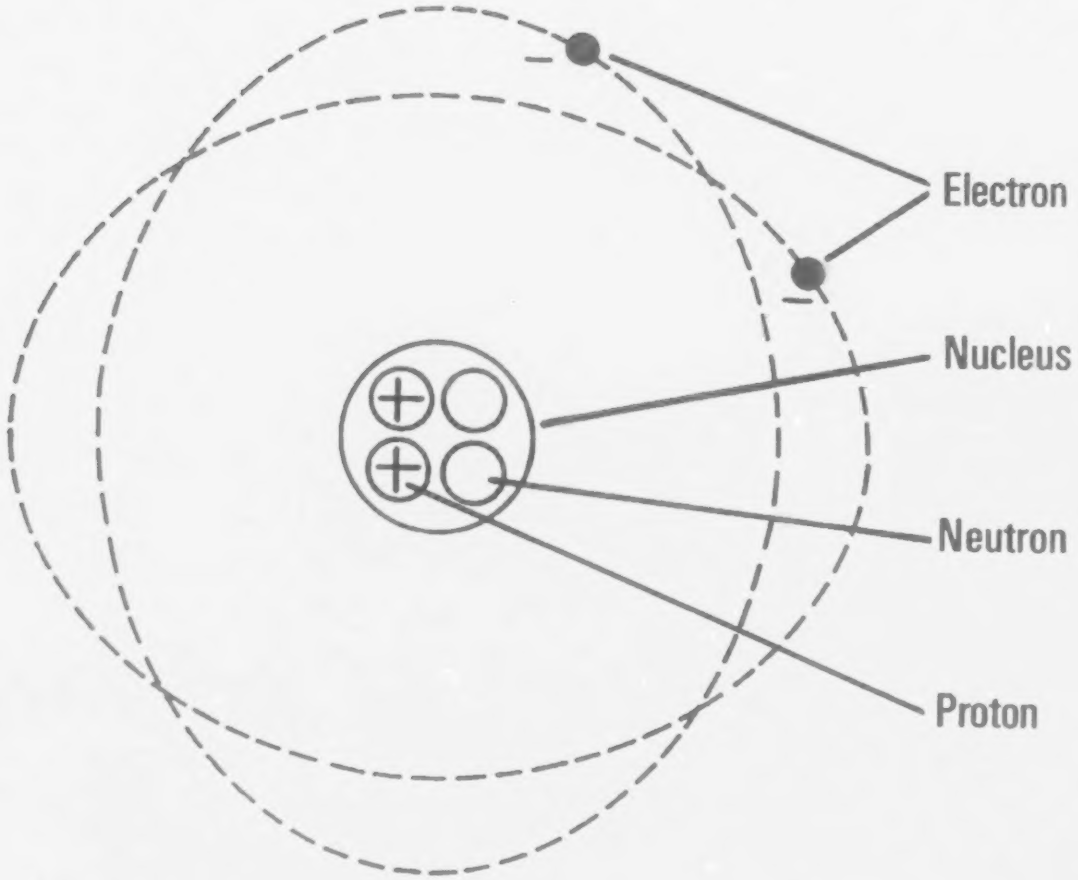




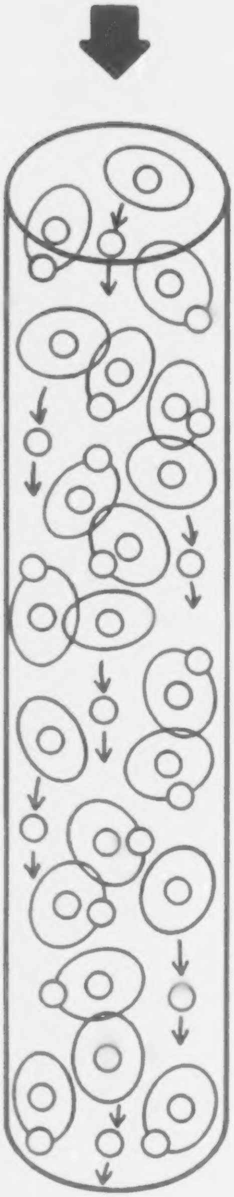
- **Sales**

- **Repair and service**

Structure of an Atom

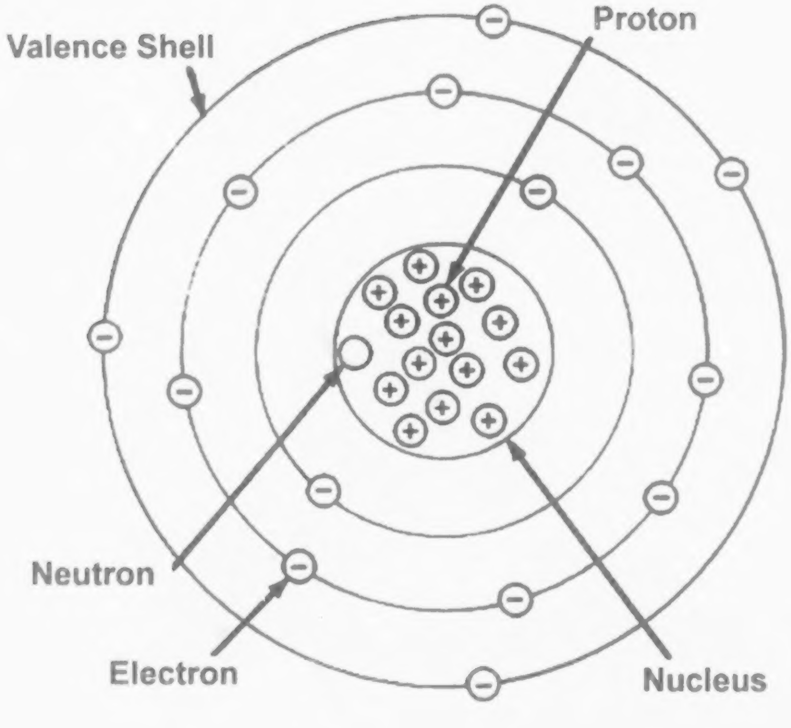

−
−
Electron
Nucleus
Neutron
Proton

Movement of Electrons

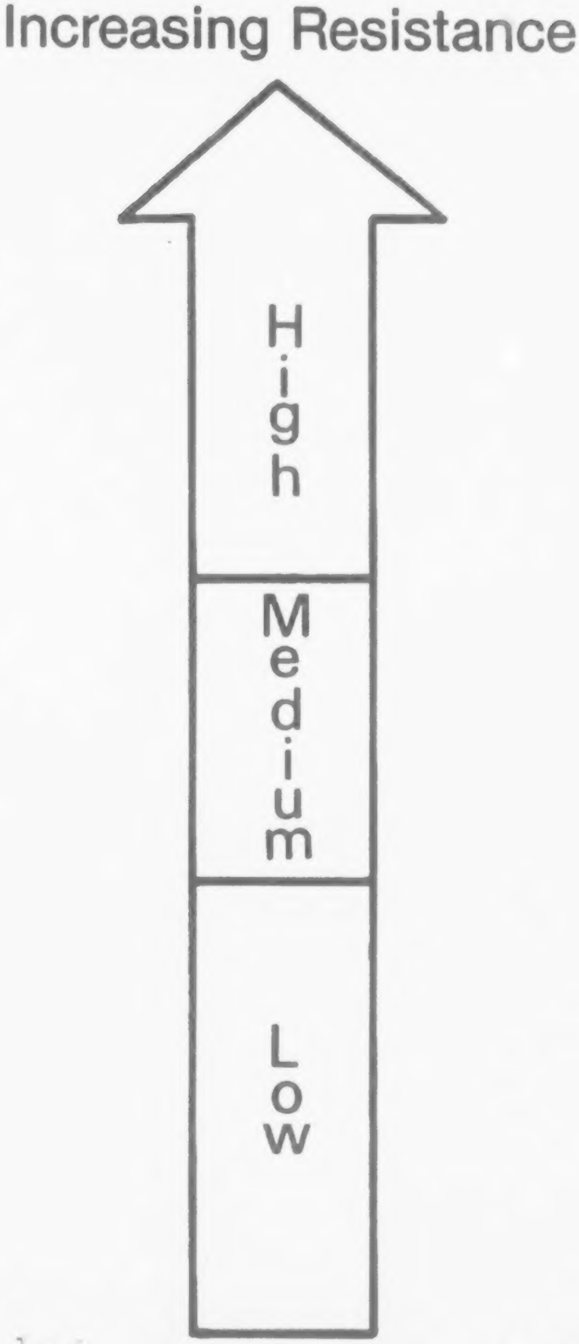


TM 3

Valence Shells


Valence Shell
Proton
Neutron
Electron
Nucleus

Resistance in Substances


Increasing Resistance
High
Medium
Low

Insulators

- Mica
- Glass
- Shellac
- Paper
- Rubber
- Bakelite
- Fiber
- Air or Vacuum

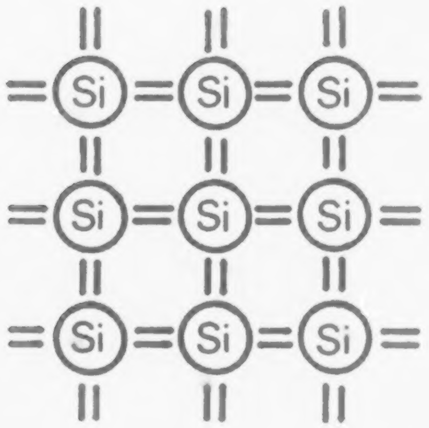
Semiconductors

- Germanium
- Silicon

Conductors

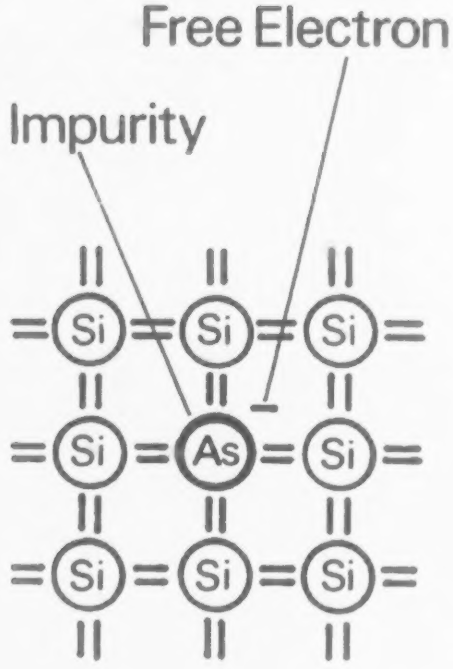
- Iron
- Nickel
- Tungsten
- Aluminum
- Gold
- Copper
- Silver

Crystalline Structure

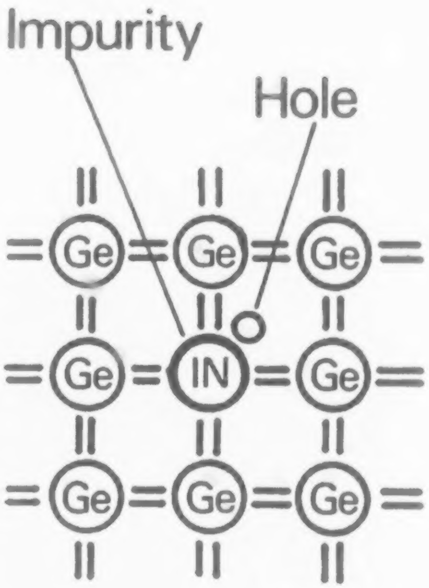

Si
Si
Si
Si
Si
Si
Si
Si
Si

Pure Silicon Crystal
Intrinsic

Doping Semiconductors

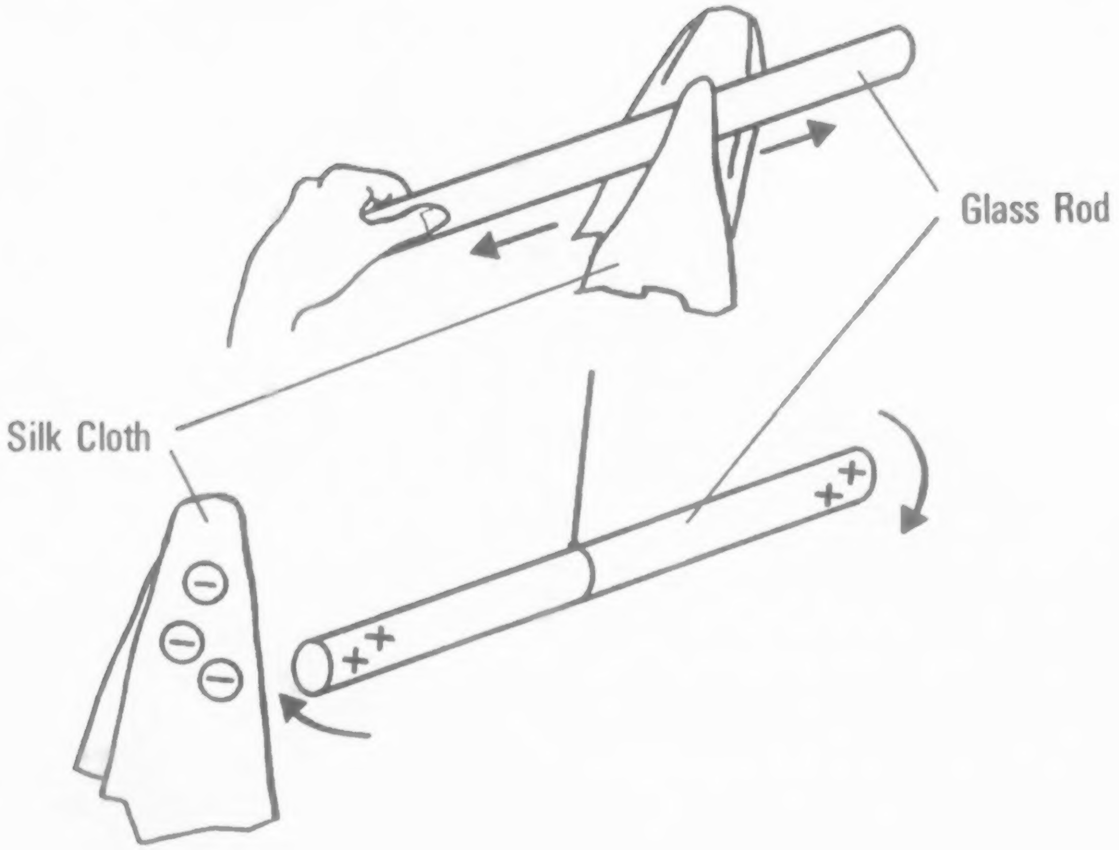

Free Electron
Impurity
Si
As
–

N-Type Silicon Crystal
Extrinsic

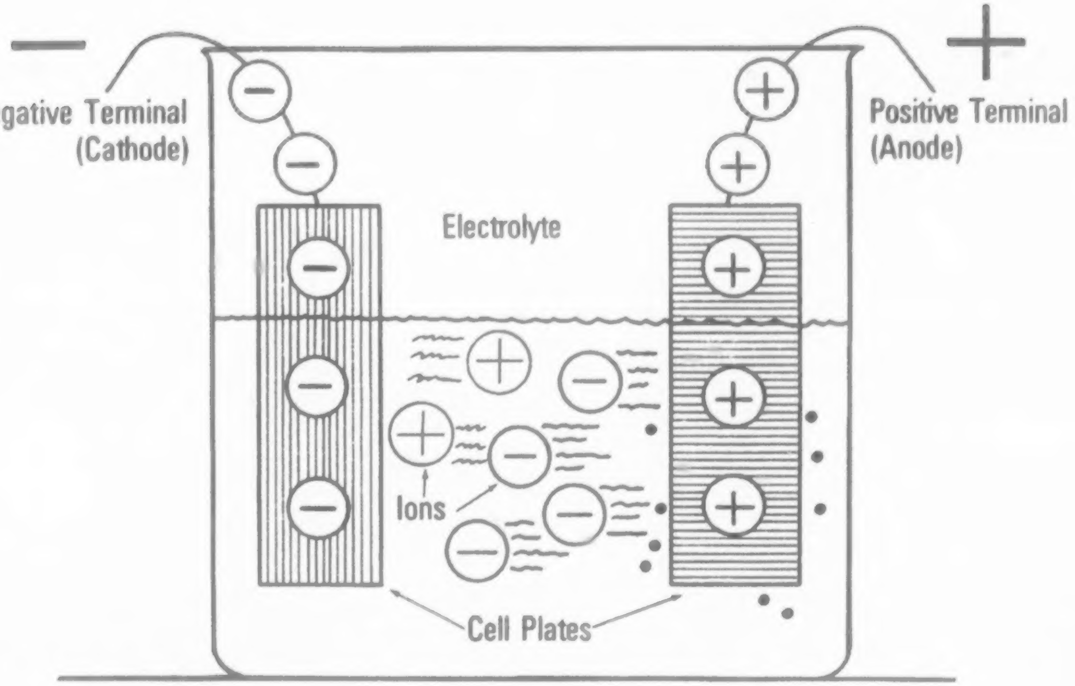

Impurity
Hole
Ge
IN

P-Type Germanium Crystal
Extrinsic

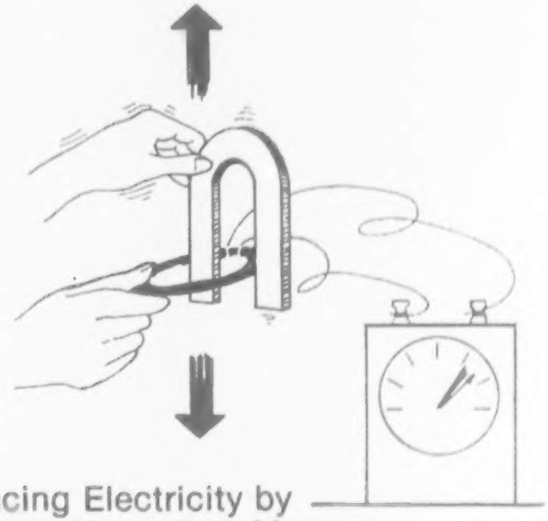
Triboelectric Effect


Glass Rod
Silk Cloth
+
+
+
+
−
−
−

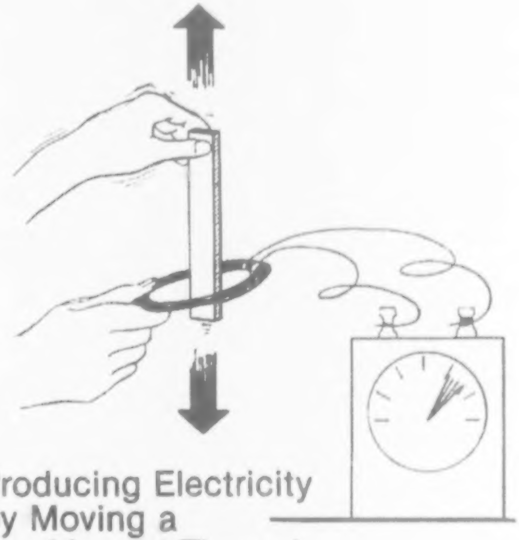
Electrochemical Reaction


—
Negative Terminal
(Cathode)
+
Positive Terminal
(Anode)
Electrolyte
Ions
Cell Plates

Electromagnetic Induction



Producing Electricity by Moving a Horseshoe Magnet Through a Coil of Wire



Producing Electricity by Moving a Bar Magnet Through a Coil of Wire

This principle is used in generators.

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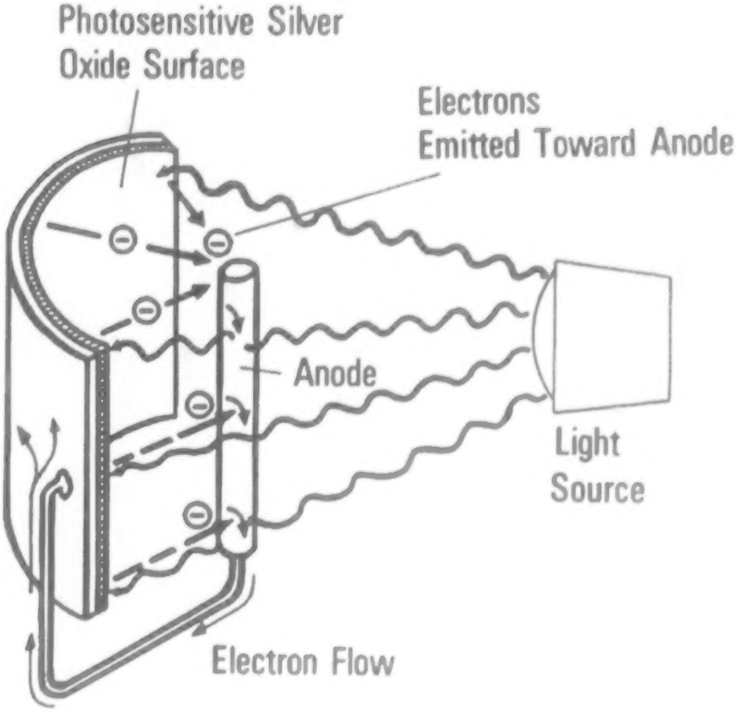
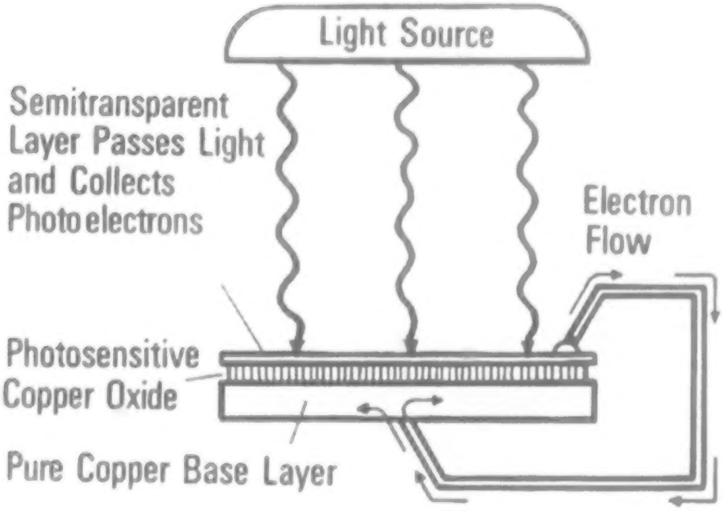
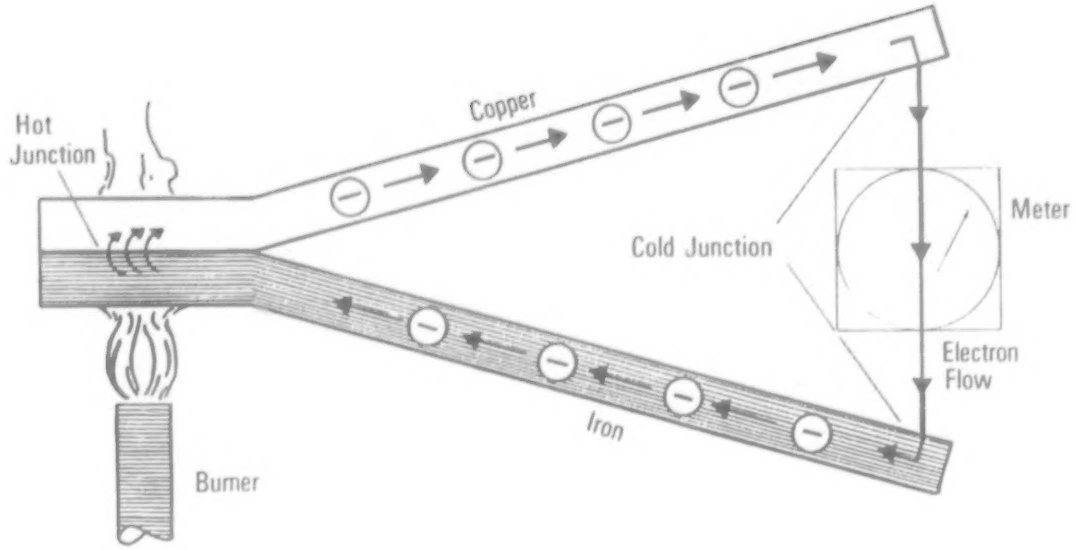
Photoelectric Effect

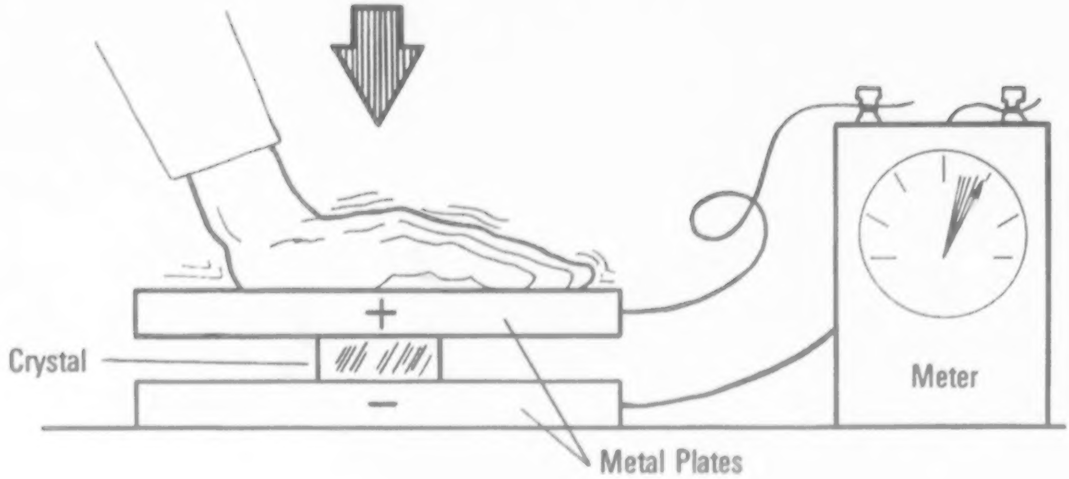

Photosensitive Silver Oxide Surface
Electrons Emitted Toward Anode
Anode
Light Source
Electron Flow


Light Source
Semitransparent Layer Passes Light and Collects Photo electrons
Electron Flow
Photosensitive Copper Oxide
Pure Copper Base Layer

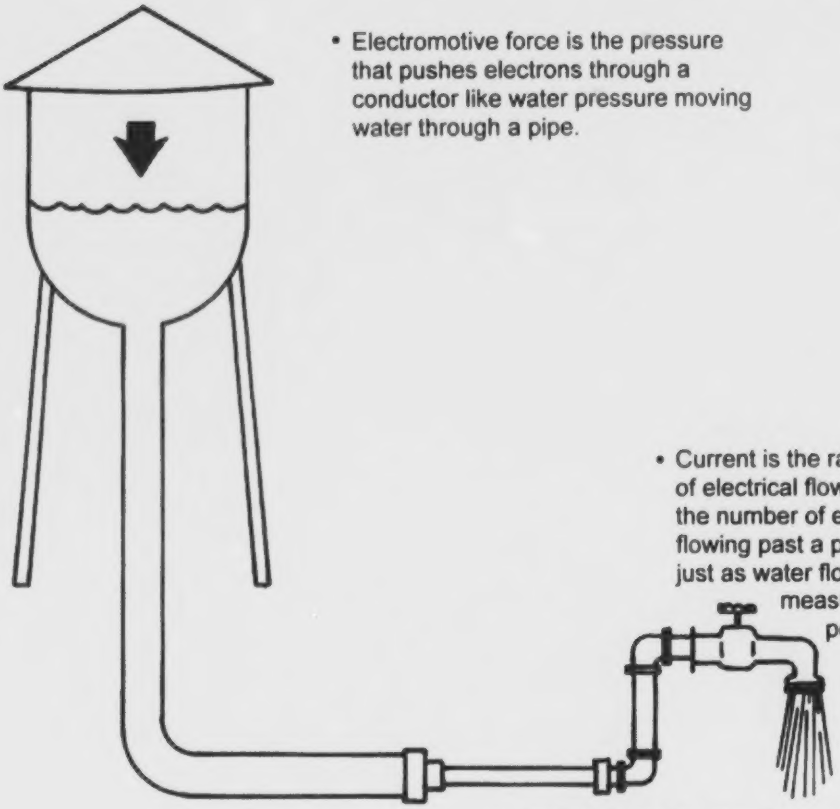
Thermoelectric Effect


Hot Junction
Copper
Meter
Cold Junction
Electron Flow
Iron
Burner

Piezoelectric Effect


+
Crystal
−
Metal Plates
Meter

Characteristics of Electrical Flow

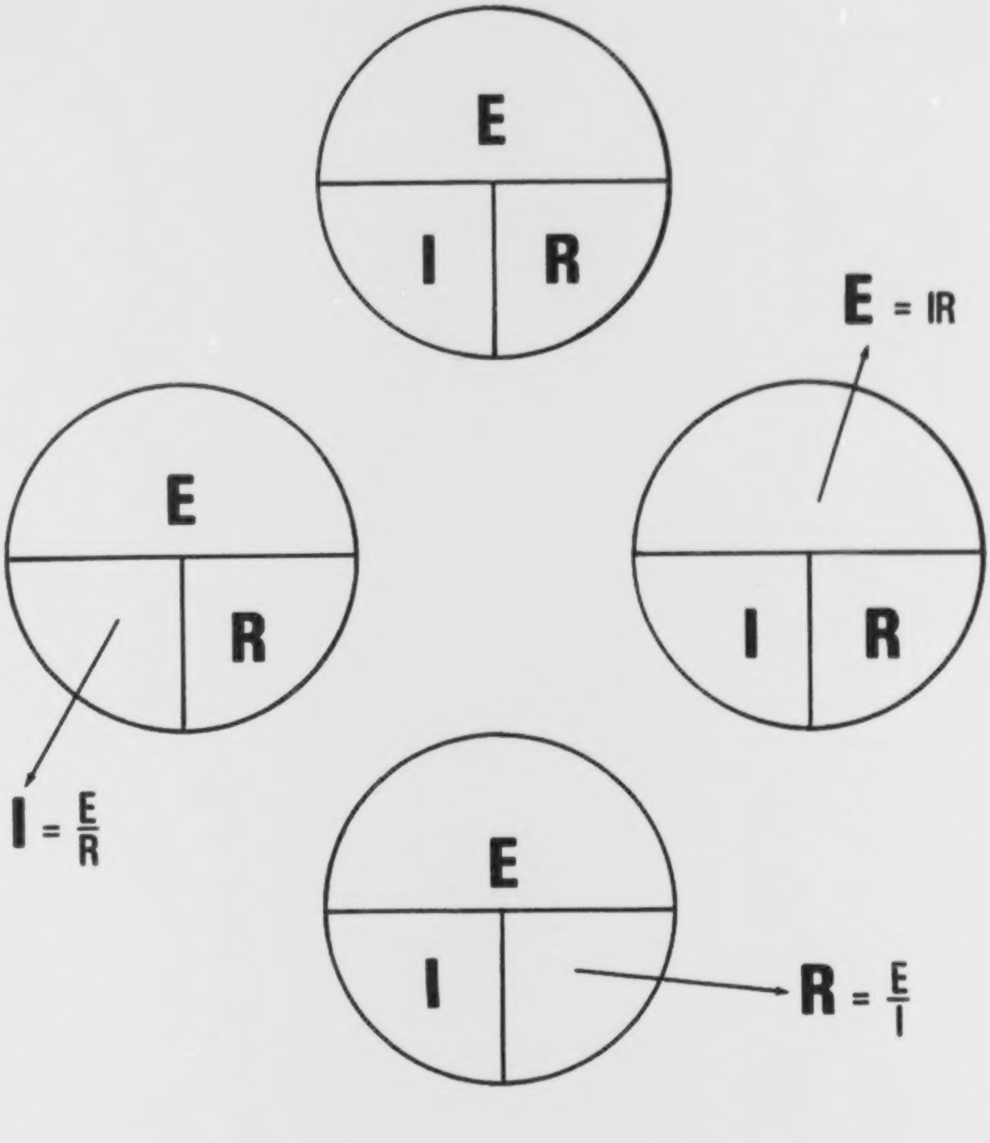


- Electromotive force is the pressure that pushes electrons through a conductor like water pressure moving water through a pipe.

- Current is the rate of electrical flow -- the number of electrons flowing past a point per second just as water flow can be measured in gallons per minute.

- Resistance is the circuit's opposition to current flow just as smaller diameter pipes resist the flow of water.

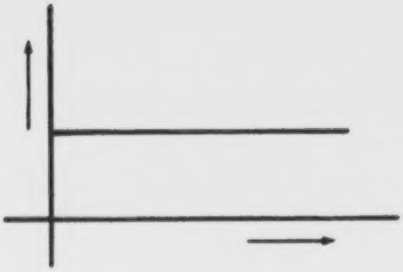
Ohm's Law


E
I
R
E = IR
E
R
I = $\frac{E}{R}$
I
R
E
I
R = $\frac{E}{I}$

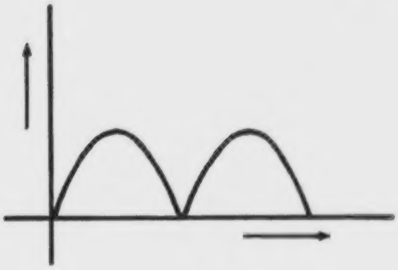
Watt's Law

- Is defined as the rate of doing work (w/t)
- Has the symbol "P"
- Can be calculated with formulas $P=IE$
 $P=I^2 R$ Watt's Law
 $P=E^2/R$
- Is measured in watts 1 watt=1 ampere x 1 volt
- Is measured by a wattmeter

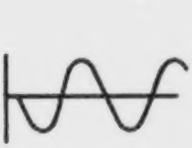
Types of Current



DC

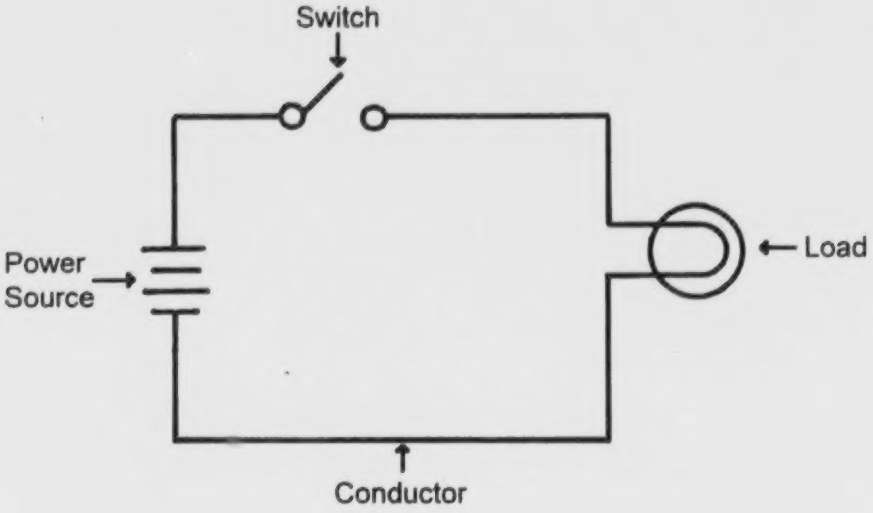


DC Pulsating



AC

Parts of a Simple Circuit


Switch
Power Source
Load
Conductor

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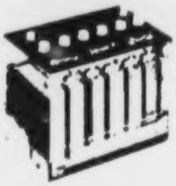
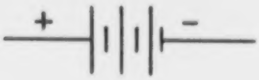
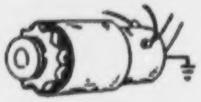
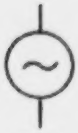
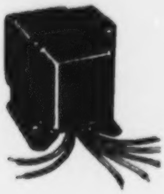
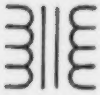
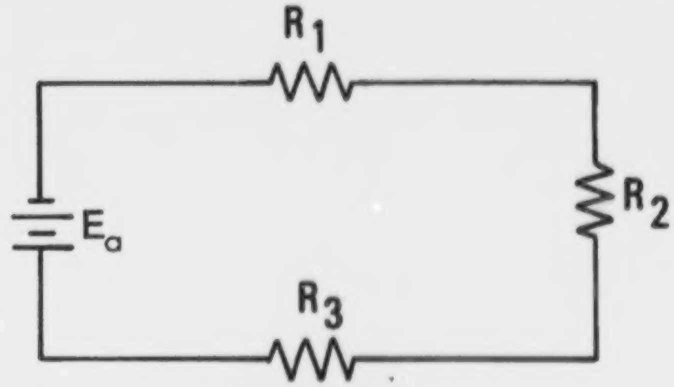
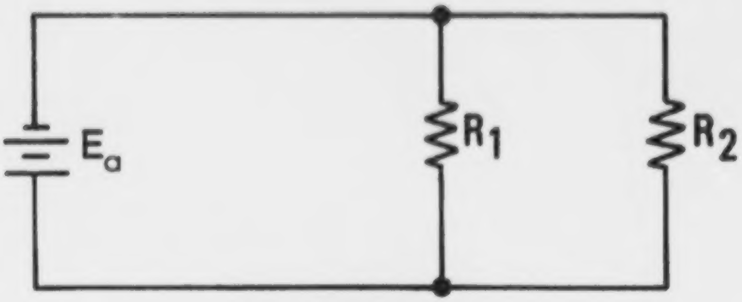
Power Sources

Element	Picture	Schematic Symbol
Battery		
Generator		 A.C.
Transformer		

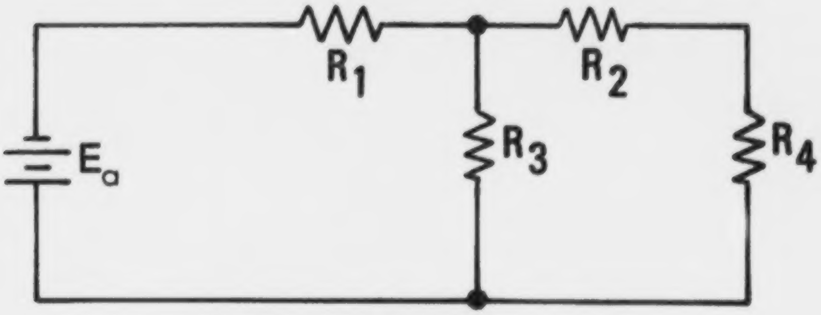
Circuit Structures



Series Circuit

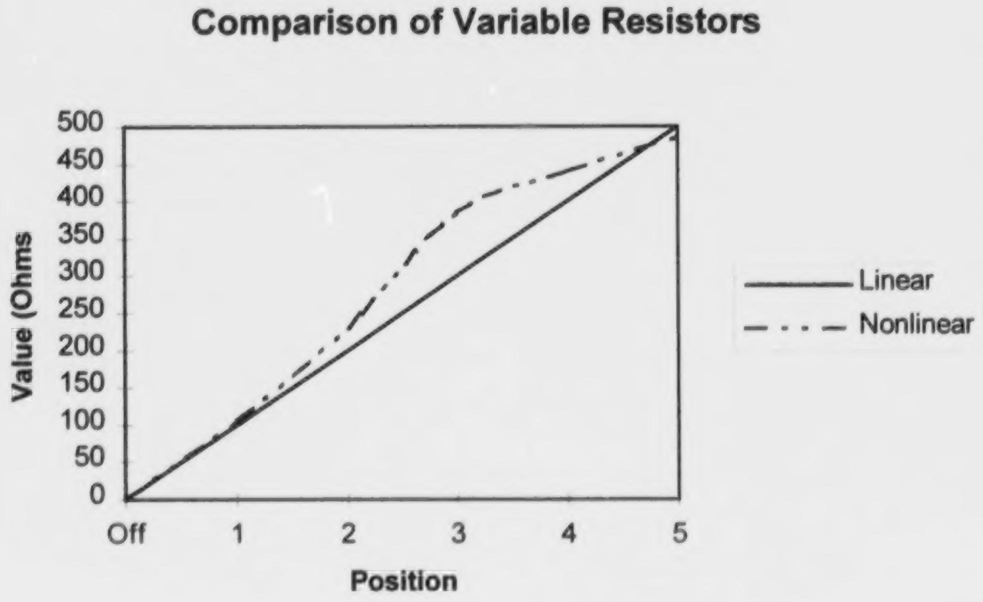


Parallel Circuit


R_1
R_2
E_a
R_3
R_4

Series-Parallel Circuit

Circuit Linearity



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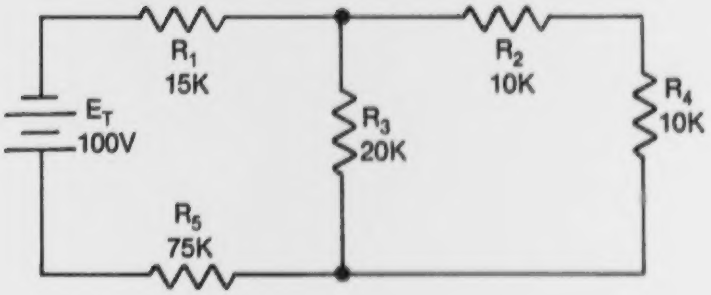
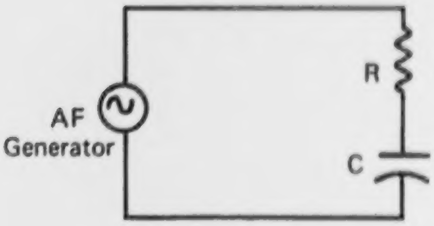
Circuit Component Classifications

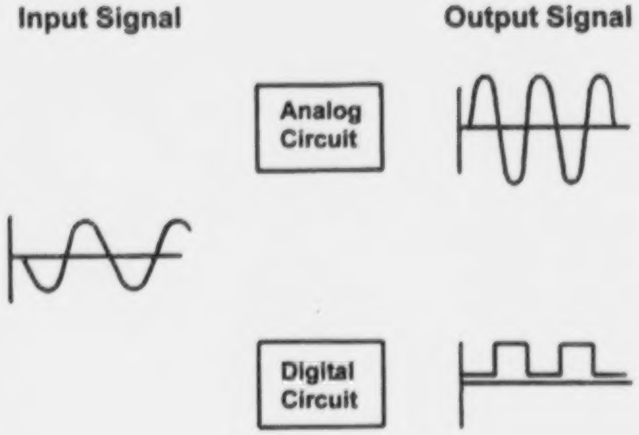

R1
15K
ET
100V
R3
20K
R2
10K
R4
10K
R5
75K

Resistive Circuit

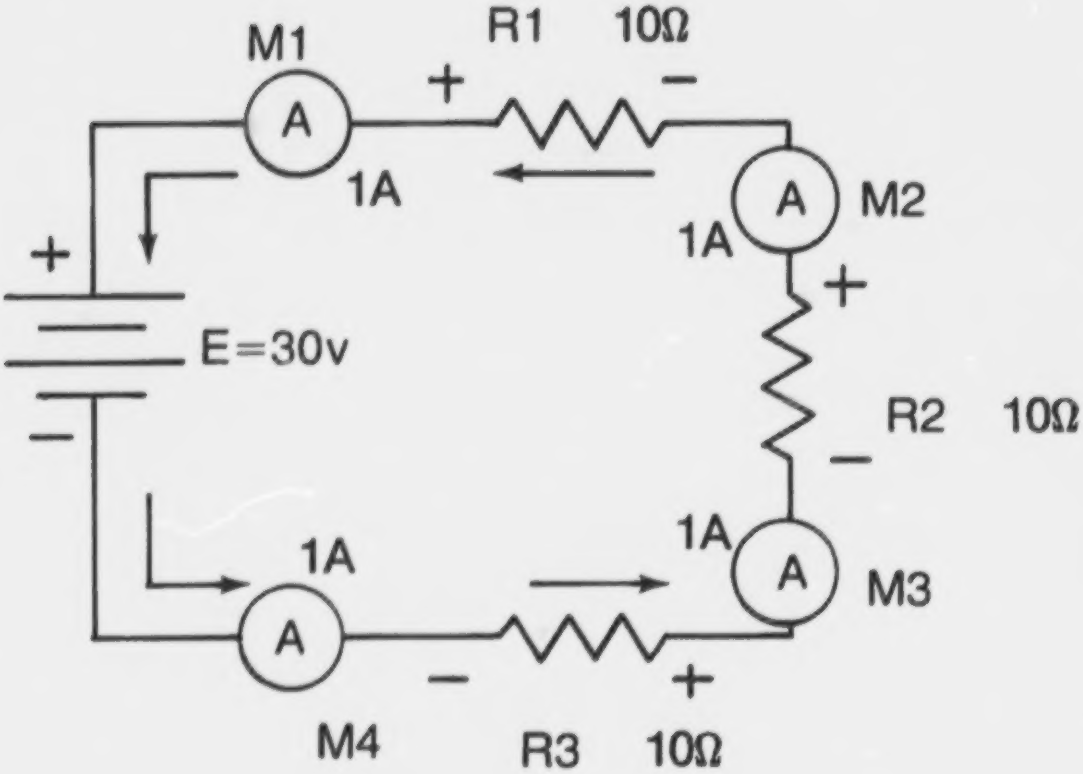

AF
Generator
R
C

Resistive-Capacitive Circuit

Types of Signals

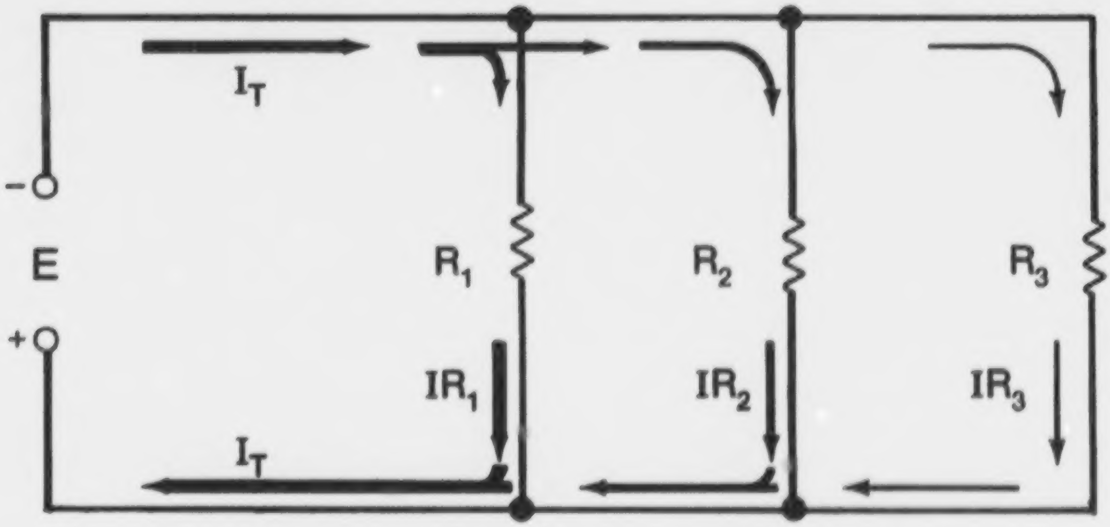

Input Signal
Output Signal
Analog Circuit
Digital Circuit

Electrical Flow in a Series Circuit


M1
R1 10Ω
+
−
A
1A
A
M2
1A
+
+
E=30v
−
R2 10Ω
−
1A
A
M3
1A
A
−
+
M4
R3 10Ω

Current measured by M1 will equal that of M2, M3 or M4.

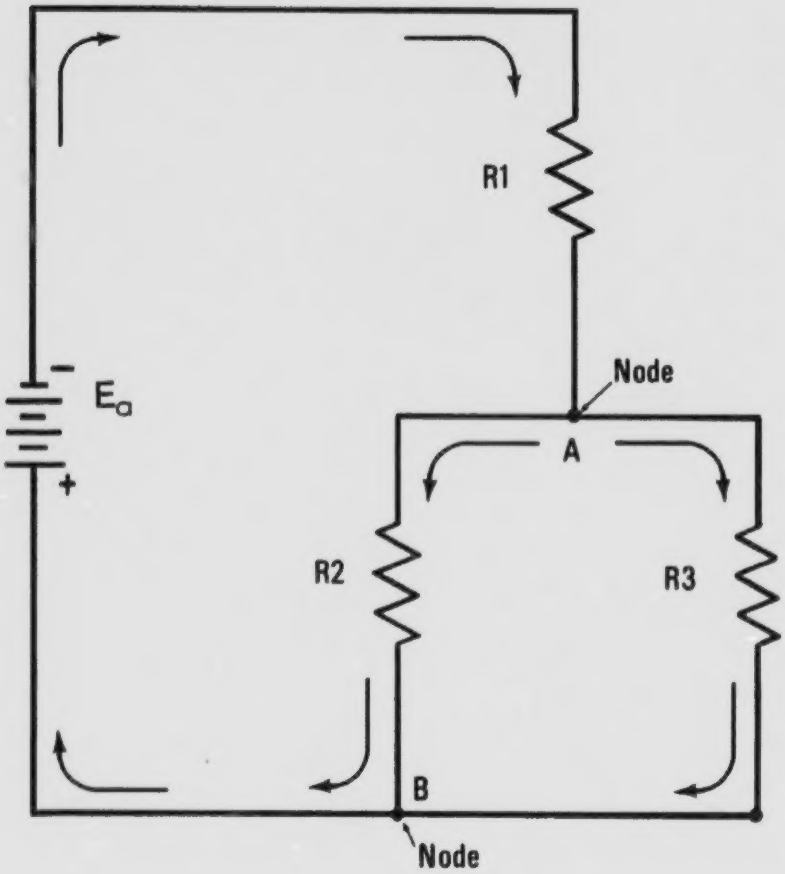
Electrical Flow in a Parallel Circuit



The total current flowing through a parallel circuit is the sum of the currents flowing through each branch.

In the above circuit: $I_T = I_{R1} + I_{R2} + I_{R3}$

Electrical Flow in a Series-Parallel Circuit


R1
Node
A
R2
R3
B
Node

E_a

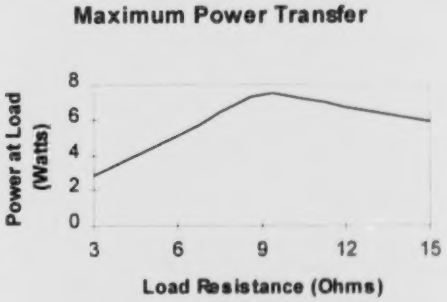
Kirchhoff's First Law

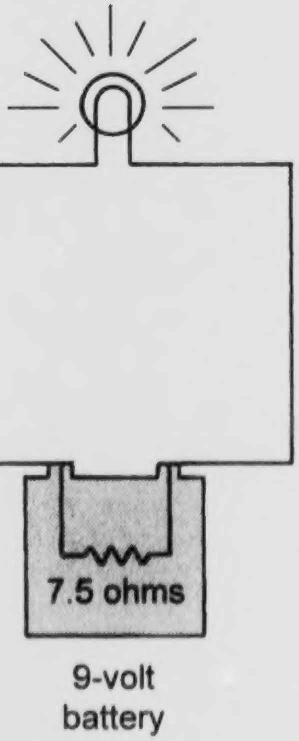
The total current flowing through a parallel circuit is the sum of the currents flowing through each branch.

Kirchhoff's Second Law

The algebraic sum of the voltages around a closed loop must equal the applied voltage.

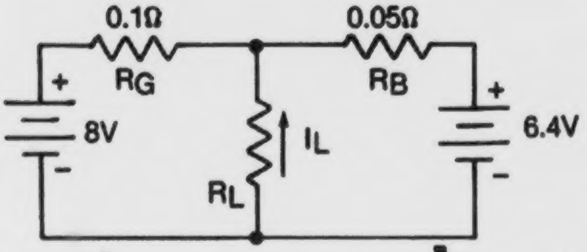
Maximum Power Transfer



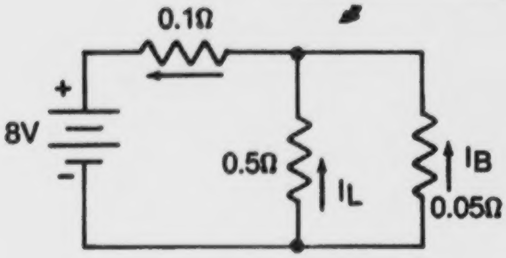

7.5 ohms
9-volt battery

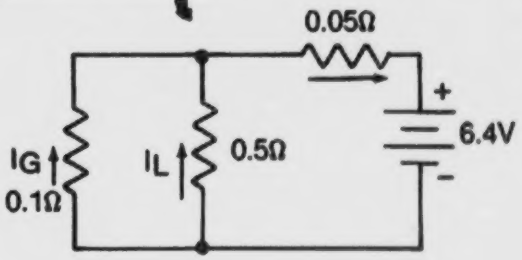
Maximum wattage when load resistance equals source resistance (7.5 ohms)

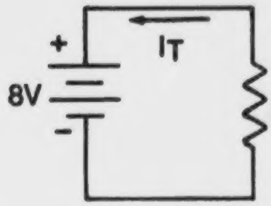
Superposition Theorem


0.1Ω
RG
0.05Ω
RB
+
8V
-
IL
RL
+
6.4V
-

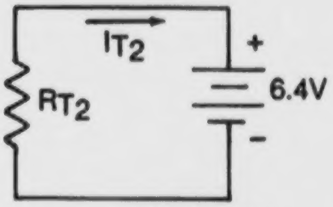
FIND: I_L


0.1Ω
+
8V
-
0.5Ω
IL
IB
0.05Ω


0.05Ω
+
6.4V
-
IG
0.1Ω
IL
0.5Ω



$R_{T1} = 0.1\Omega + \frac{(0.5)\ (0.05)}{0.5\ +\ 0.05}\ \Omega$



$I_{T1} = \frac{8V}{0.145} = 55$ AMP

$I_{T1} = I_B + I_L$

AND $I_B = 10I_L$

$\therefore I_{T1} = 11I_L + I_L$

$55 = 11I_L,\ I_L = 5$ AMP

CONCLUSION:
SINCE THESE TWO CURRENTS PASS THROUGH R_L IN THE SAME DIRECTION

I_L TOTAL = 5+8 = 13 AMP

$R_{T2} = 0.05\Omega + \frac{(0.1)\ (0.5)}{0.1\ +\ 0.5}\ \Omega$

$R_{T2} = 0.133\Omega$

$I_{T2} = \frac{6.4V}{0.133\Omega} = 48$ AMP

$I_{T2} = I_G + I_L$

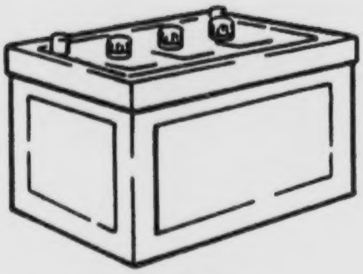
$I_G = 5I_L$

$\therefore I_{T2} = 5I_L + I_L$

$48 = 6I_L$

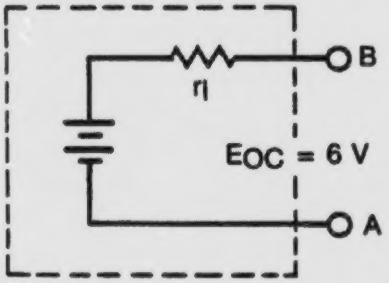
$I_L = 8$ AMP

Thévenin's Theorem

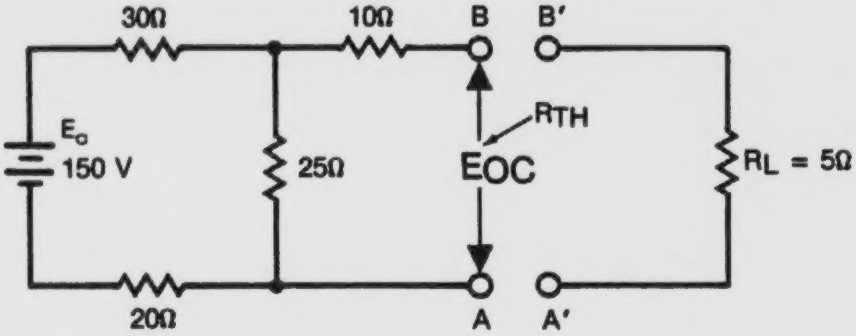


Six Volt Battery

=



Constant Voltage Source


30Ω
10Ω
B
B'
Eo
150 V
25Ω
RTH
EOC
RL = 5Ω
20Ω
A
A'

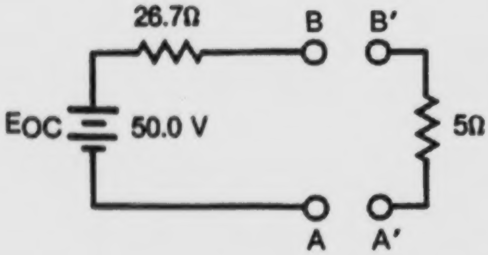
$$E_{OC} = 150\left(\frac{25}{30 + 20 + 25}\right) = 50.0\text{V}$$

$$R_{TH} = 10 + \frac{(25)\ (30 + 20)}{25 + 30 + 20}$$

$$R_L = 10 + 16.7$$

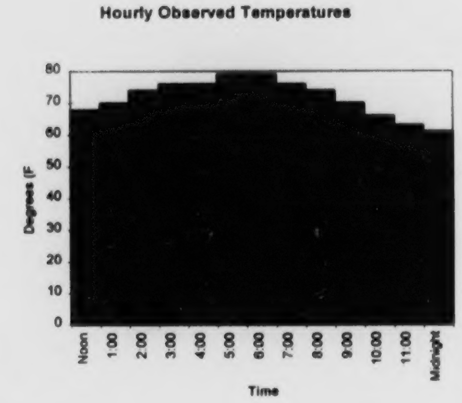
$$R_L = 26.7\Omega$$

$$I_{5\Omega} = \frac{50}{26.7 + 5} = 1.575 \text{ AMP}$$

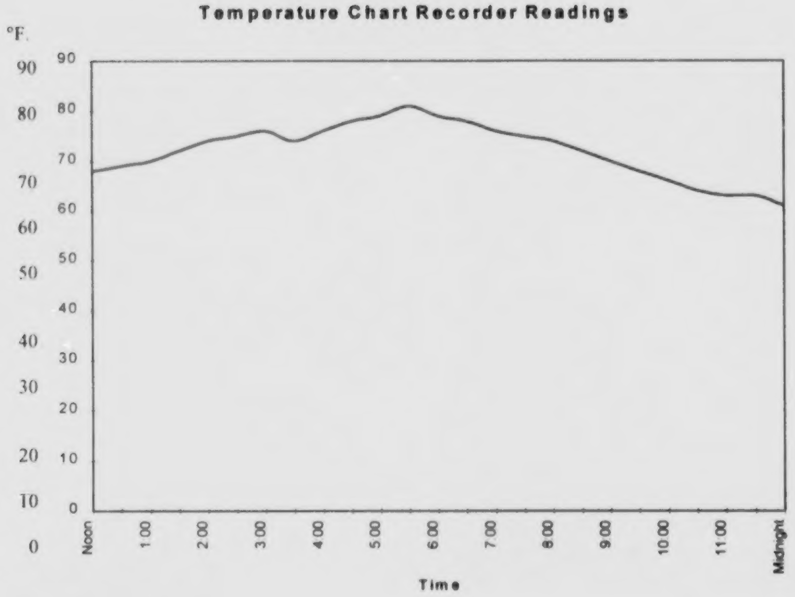

26.7Ω
B
B'
EOC
50.0 V
5Ω
A
A'

Types of Electronic Signals

Digital

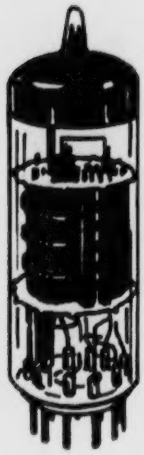


Analog

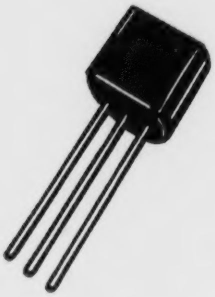


BEST COPY AVAILABLE

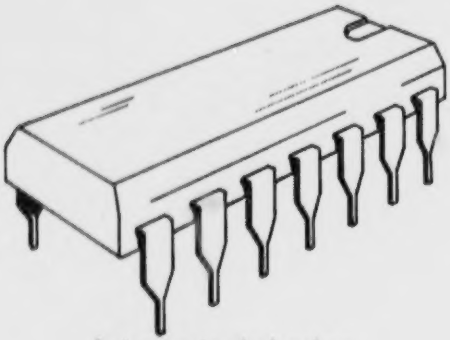
Categories of Electronic Devices



Electron tube

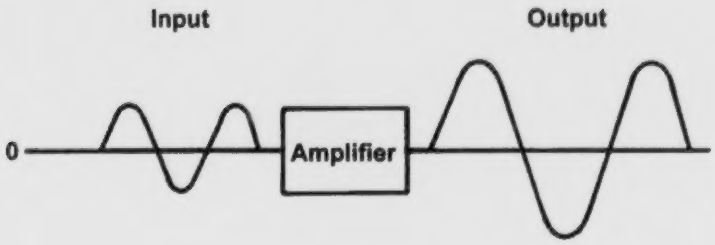


Solid-state device

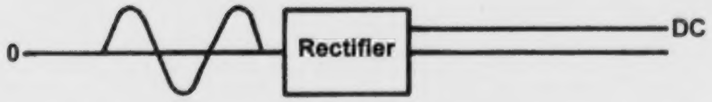


Integrated device

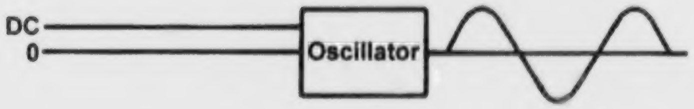
Functions of Electronic Devices


Input
Output
0
Amplifier

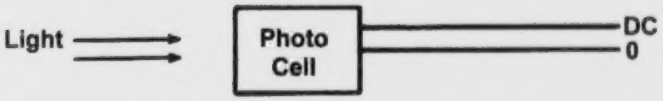
Amplification


0
Rectifier
DC

Switching

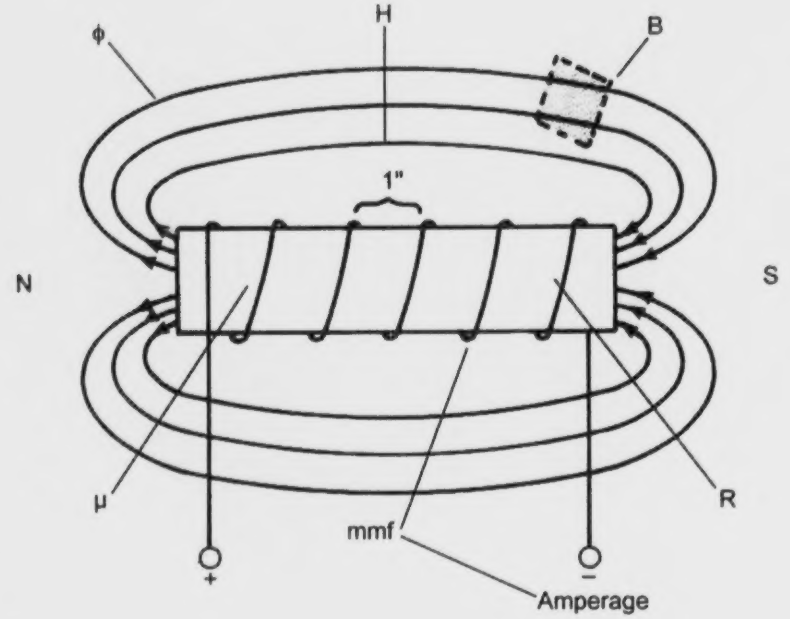

DC
0
Oscillator

Oscillation

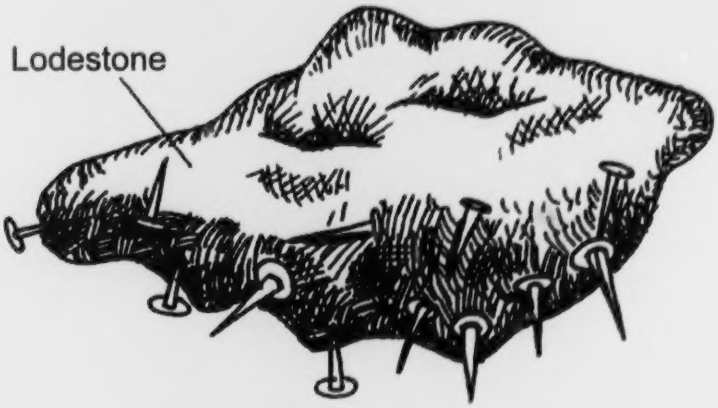

Light
Photo
Cell
DC
0

Energy Conversion

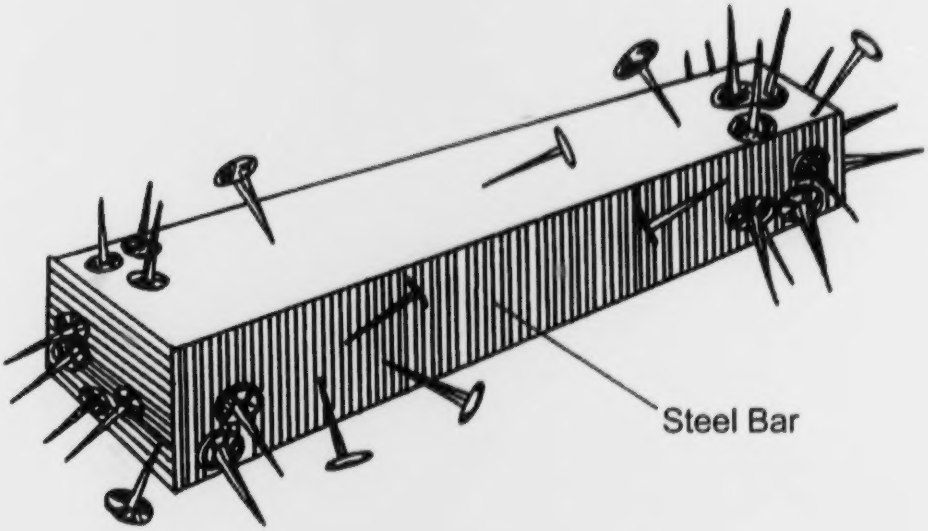
Magnetic Properties


ϕ
H
B
1"
N
S
μ
R
mmf
Amperage
+
−

Ways of Classifying Magnets

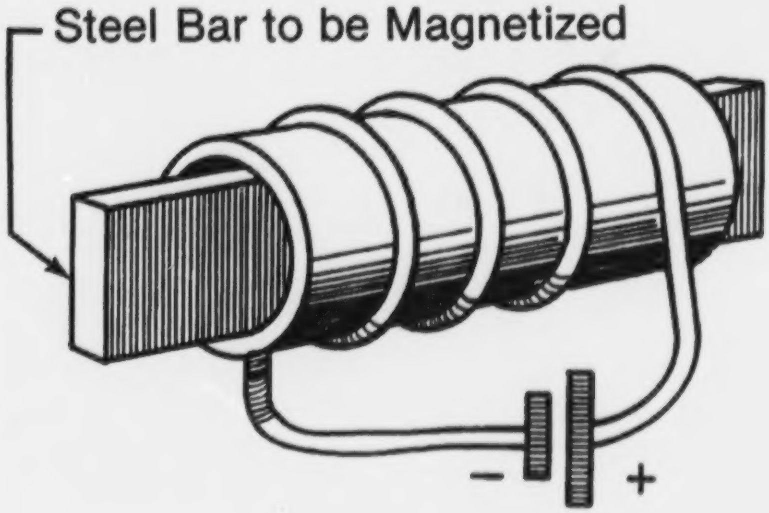


Natural

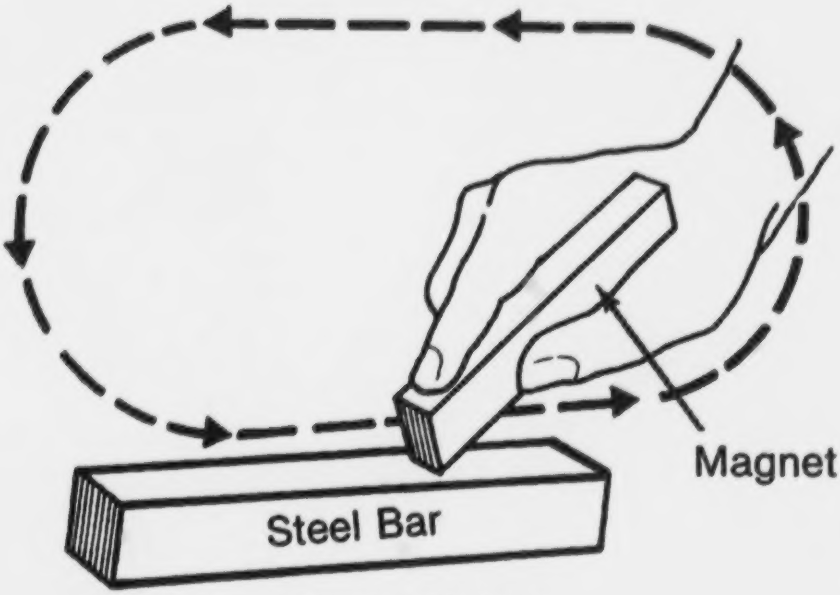


Artificial

Ways of Classifying Magnets (Continued)


Steel Bar to be Magnetized
−
+

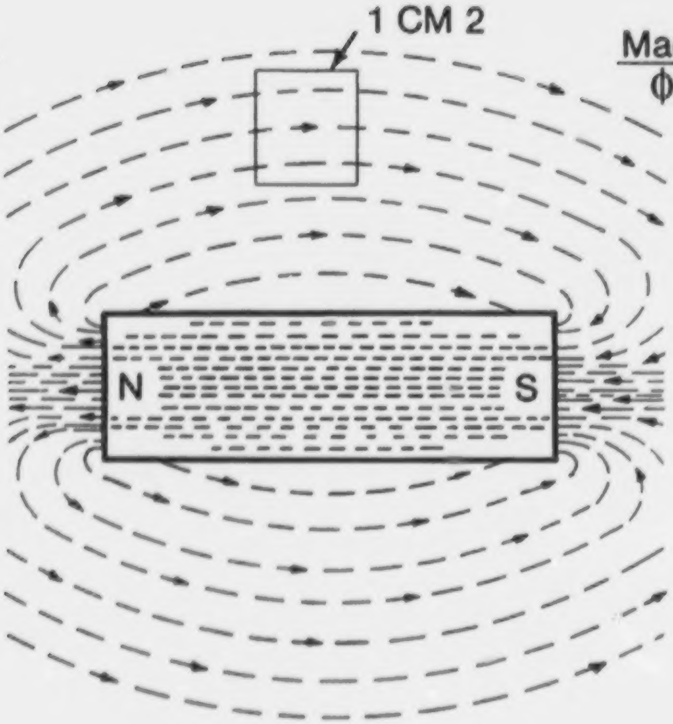
Coil Method


Magnet
Steel Bar

Stroking Method

TM 37

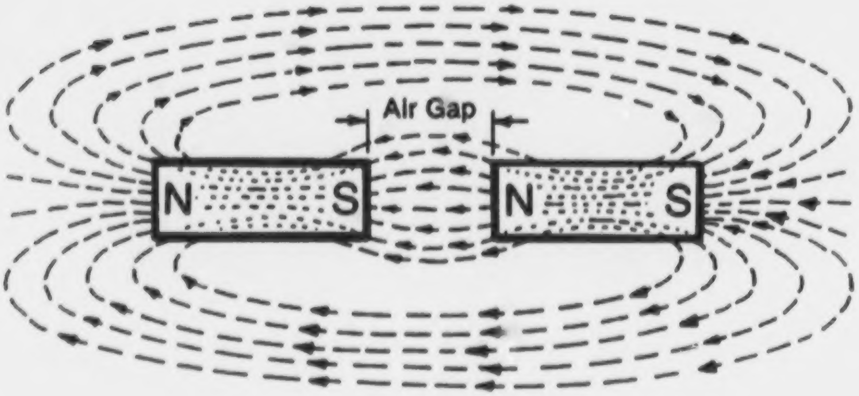
Magnetic Flux



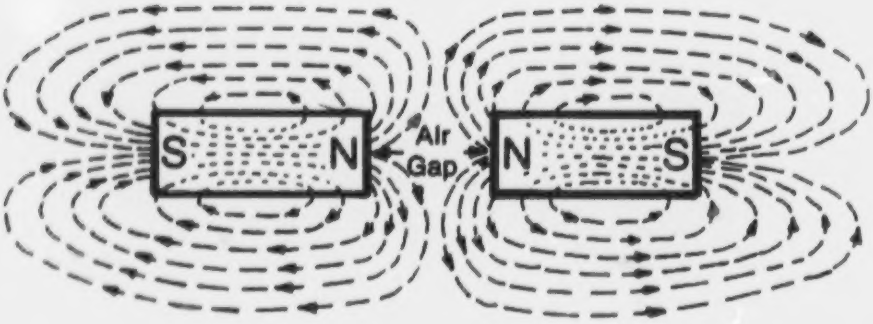
Flux Density
$B = 4\ G$

Magnetic Flux
$\phi = 14\ Mx$

Magnetic Pole Interaction


Air Gap
N
S
N
S

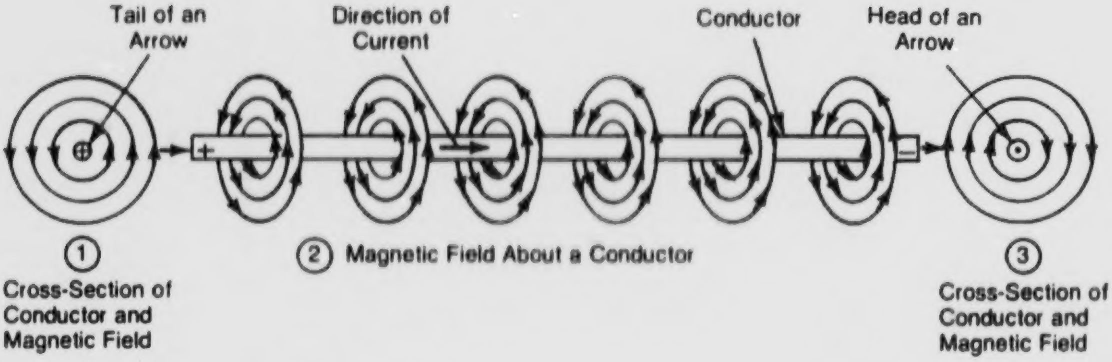
Unlike Poles Attract


S
N
Air Gap
N
S

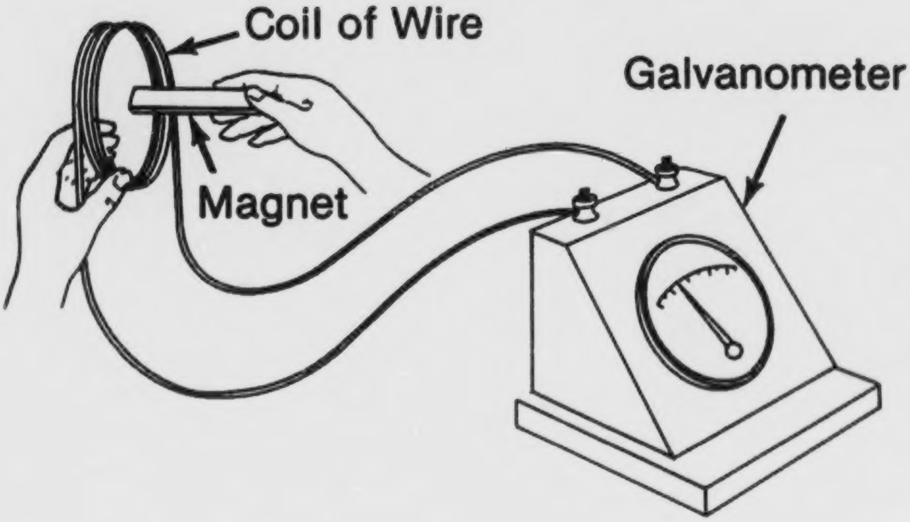
Lines of Force

Like Poles Repel

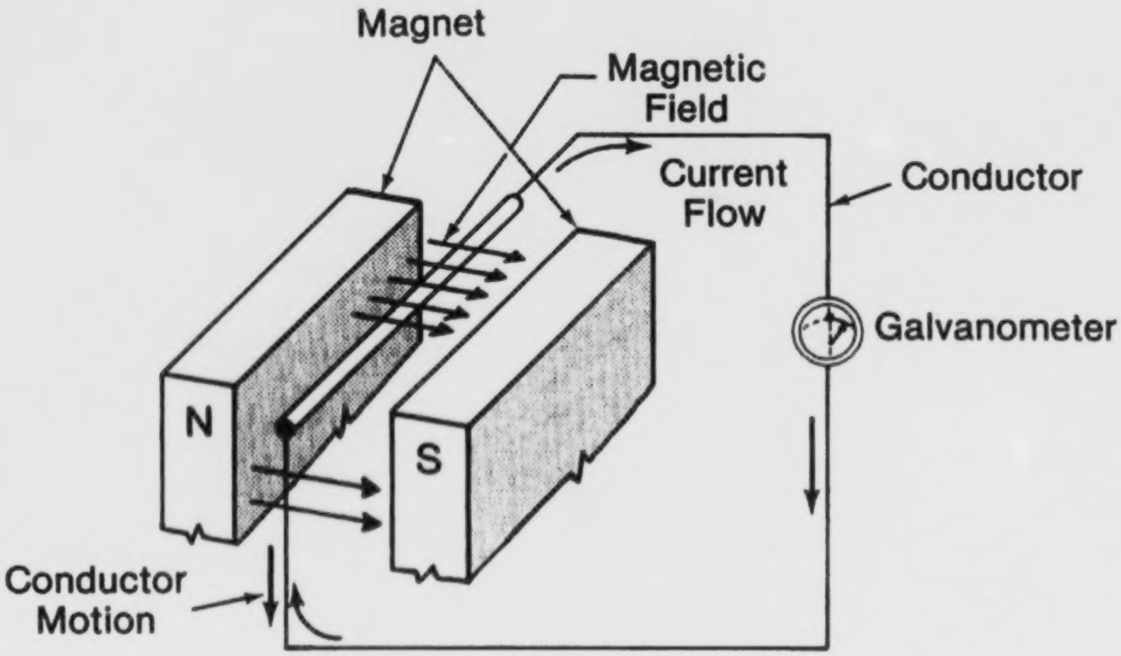
Electromagnetism


Tail of an Arrow
Direction of Current
Conductor
Head of an Arrow
+
−
①
Cross-Section of Conductor and Magnetic Field
② Magnetic Field About a Conductor
③
Cross-Section of Conductor and Magnetic Field

Magnetic Induction


Coil of Wire
Galvanometer
Magnet

Electromagnetic Induction


Magnet
Magnetic Field
Current Flow
Conductor
Galvanometer
N
S
Conductor Motion

Shop Orientation and Safety
Unit 2

Suggested Activities

Instructional Plan

Preparation

- Review unit and plan presentation. Study the specific objectives to determine the order in which you will present the objectives.

  Review the unit introduction and teaching suggestions included in the delivery and application section below, and plan classroom activities. Also note the suggestions for media and supplemental materials.

  Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.

- Obtain films, videotapes, and other media to supplement instruction of this unit. See ordering information in the suggested resources section.

- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only and should be used with objectives as indicated below.

  TM 1—Parts of a Typical Electronics Workstation (Objective 2)
  TM 2—General Hand Tools (Objective 7)
  TM 3—General Hand Tools (Continued)(Objective 7)
  TM 4—General Hand Tools (Continued)(Objective 7)
  TM 5—General Hand Tools (Continued)(Objective 7)
  TM 6—General Hand Tools (Continued)(Objective 7)
  TM 7—General Hand Tools (Continued)(Objective 7)
  TM 8—Wire Preparation and Assembly Tools (Objective 9)
  TM 9—Soldering Tools (Objective 10)
  TM 10—Soldering Tools (Continued) (Objective 10)
  TM 11—Soldering Tools (Continued) (Objective 10)
  TM 12—Electronic Component Handling and Preparation Tools (Objective 11)
  TM 13—Electronic Component Handling and Preparation Tools (Continued) (Objective 11)
  TM 14 –Electronic Test Equipment and Inspection Tools (Objective 12)
  TM 15—Electronic Test Equipment and Inspection Tools (Continued) (Objective 12)
  TM 16—Analog Voltmeter (Objective 13)
  TM 17—Ammeter (Objective 13)

Suggested Activities

TM 18—Ohmmeter (Objective 13)
TM 19—Multimeter (Objective 13)
TM 20—Moving Coil Meter (Objective 14)
TM 21—Taut-Band DC Meter (Objective 14)
TM 22—Electrodynamometer (Objective 14)
TM 23—Iron Vane Meter (Objective 14)
TM 24—Thermocouple Meter (Objective 14)
TM 25—Ammeter Operation (Objective 15)
TM 26—Voltmeter Operation (Objective 16)
TM 27—Ohmmeter Operation (Objective 17)
TM 28—Digital Meter Functional Blocks (Objective 18)
TM 29—Oscilloscope Controls (Objective 19)
TM 30—Oscilloscope Block Diagram (Objective 20)
TM 31—Cathode Ray Tube (Objective 20)
TM 32—CRT Signal Trace (Objective 20)
TM 33—Parts of a Waveform (Objective 22)
TM 34—Phase Relationships (Objectives 22 and 42)
TM 35—Lissajous Phase Patterns (Objectives 22 and 42)
TM 36—Lissajous Phase Patterns (Continued)(Objectives 22 and 42)
TM 37—Electric Shock Versus Body Sensations (Objective 30)
TM 38—Components of the Fire Triangle (Objective 34)
TM 39—Classes of Fires and Fire Extinguisher Markings (Objectives 34)
TM 40—How to Lift Safely (Objective 43)
TM 41—How to Lift Safely (Continued) (Objective 43)

- Select teacher components (supplements, written test, unit evaluation form) you want to distribute to your students. Copy and prepare these components for distribution. The supplements included in this unit are designed for use with the objectives as indicated below.

Supplement 1—Tour an Electronics Workplace (Various Objectives)
Supplement 2—Guidelines for Interpreting MSDSs (Objective 36)
Supplement 3—Sample MSDSs (Objective 36)
Supplement 4—Locate and Report on an MSDS (Objective 36)
Supplement 5—Survey Facility Fire Extinguishers (Objective 44)
Supplement 6—American Red Cross First-Aid Procedures Booklet (Objective 38)
Supplement 7—Using Portable Fire Extinguishers (Objective 44)
Supplement 8—Determine the Resistance of a Meter Movement (Objective 13)
Supplement 9—Construct and Analyze a Voltmeter (Objective 16)
Supplement 10—Construct and Analyze an Ohmmeter (Objective 17)

Suggested Activities

Supplement 11—Construct and Analyze an Ammeter (Objective 15)
Supplement 12—Conduct an Electrical Survey of Your Facility (Objective 24)
Supplement 13—Conduct an Environmental Survey of Your Facility (Objective 24)

- Prepare classroom. Put up posters and charts and display articles and other references related to the objectives of this unit. As the class year continues, safety posters should be changed periodically to be effective and to emphasize to students that they are displayed to do more than just support this unit.

Delivery and Application

Unit Introduction

- Discuss unit and specific objectives.
- Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets and job sheets. Review with students the criteria for evaluation of each of these activities.

Teaching Suggestions

The skill areas appearing in bold-face type in the teaching suggestions refer to the academic and workplace skills identified in *What Work Requires of School: A SCANS Report for America 2000* and *Workplace Basics: The Skills Employers Want*. These have been adapted by MAVCC.

- Visit electronics companies or tour your own facilities to show the students workstations, equipment, tools, storage areas, fire extinguishers, evacuation routes, power controls, and other features related to this unit. **(Listening; seeing things in the mind's eye; responsibility; materials and resources)**
- Display components that have been damaged by electrostatic discharge. Clearly explain your facility's policies on handling ESD-sensitive components. Demonstrate the buildup of static electricity. Demonstrate the correct use of ESD reduction and monitoring devices. Stress that not all damage is visible and that sometimes ESD events simply degrade the component or assembly. **(Listening; science; applying technology; adapting to the organization's goals and values)**

Suggested Activities

- Demonstrate the tools used in your facility and explain your policies regarding care and cleaning of tools. Emphasize the safe use of all tools. Use the appropriate supplements to help students understand the operation of meters and other test equipment. Demonstrate the operation and use of an oscilloscope and the equipment often used in conjunction with one (function generators, signal generators, etc.). Allow the students to practice adjusting waveform displays. **(Listening; seeing things in the mind's eye; applying technology; selecting tools and procedures)**

- Invite a resource person from the Red Cross or a medical organization to discuss emergencies and first-aid. Provide CPR training and practice on resuscitation dummies if at all possible. Review the location of first-aid kits and their contents. Point out the location and demonstrate the use of other safety equipment, such as eye wash stations and stretchers. Invite personnel who have suffered on-the-job injuries, especially in the electronics industry, to discuss their experiences. Review the specific safety rules used in your program. **(Listening; reasoning; applying technology; adapting to the organization's goals and values)**

- Invite an OSHA, EPA, or other government representative to discuss the role of such agencies. Point out safety precautions that have resulted from the involvement of such agencies, such as the reduction in the use of CFC solvents. **(Listening; seeing things in the mind's eye; adapting to the organization's goals and values)**

- Acquaint the students with the hazardous materials used in your facility. Show them the location of MSDSs and review the more important ones. Discuss storage, issue, and disposal procedures. Review any hazardous materials plans your facility may use, including a presentation by your facility's HAZMAT coordinator. Point out placards and other signs exhibited at your facility to indicate hazardous materials. Demonstrate the use of any special equipment required as a result of hazardous materials, such as respirators, spill dams, leak detectors, etc. **(Listening; adapting to the organization's values and traditional modes of operation; acquiring and evaluating information; applying technology)**

- Invite a resource person from the fire department to discuss fire hazards and fire fighting. Work with the fire department to set up an area where you can complete Job Sheet 2. **(Listening; applying technology; selecting tools and procedures)**

Suggested Activities

Evaluation

- Discuss with students the use of the Unit Evaluation Form. Explain the rating scale that will be used for student evaluation.
- Copy written test and give to students as pretest. Record pretest score on the Unit Evaluation Form.
- Evaluate assignment sheets. See the evaluation criteria listed at the top of each assignment sheet and the component "Answers to Assignment Sheets."
- Evaluate job sheets. See the evaluation criteria listed at the top of each job sheet.
- Give and evaluate written test.
- Compile written-test, assignment-sheet, and job sheet scores on the Unit Evaluation Form. Include any additional assignments.
- Measure competency gains by comparing written pretest scores with posttest scores.
- Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas of improvement.
- Reteach and retest as required.

Instructions for Evaluating Student Performance

- When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

  Sample performance evaluation keys have been provided on the next page. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Suggested Activities

Option A

4 — Skilled—Can perform job with no additional training.
3 — Moderately skilled—Has performed job during training program; limited additional training may be required.
2 — Limited skill—Has performed job during training program; additional training is required to develop skill.
1 — Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Suggested Resources

Resources Used in Developing This Unit

- *American Red Cross Standard First Aid.* Washington, DC: American Red Cross, 1989.
- *Basic Electronics.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1987.
- *Communications Electronics.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1988.
- Davidson, Homer L. *Troubleshooting and Repairing Compact Disc Players.* 2nd Ed. New York, New York: TAB Books, 1994.
- *Family Medical Guide.* New York, NY: Better Homes and Gardens Books, Meredith Corporation, 1993.
- *General Electronics Technician.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1987.
- *Graphic Symbols for Electrical and Electronics Diagrams.* New York: Institute of Electrical and Electronics Engineers, Inc., 1975.
- *Home Electronics.* Alexandria, Virginia: Time-Life Books, 1988.
- Roehrig, Guido and Ulrich Schueller. *Upgrading and Maintaining Your PC.* Grand Rapids, Michigan: Abacus, 1991.

Suggested Activities

- Schuler, Charles A. *Electronics Principles and Applications.* 4th edition. New York: Glencoe Division, Macmillan/McGraw-Hill School Publishing Company, 1994.
- Sclater, Neil. *Electrostatic Discharge Protection for Electronics.* Blue Ridge Summit, Pennsylvania; TAB Books, 1990.
- Simpson, Colin D. *Principles of DC/AC Circuits.* Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1996.

Supplemental Resources

Print Media

- *American Red Cross Community First Aid and Safety.* Washington, DC: American Red Cross, 1993.
- *MSDS Pocket Dictionary.* Schenectady, New York: Genium Publishing Corporation, 1989.

Non-print Media

Note: You may want to check with the manufacturers of equipment used in your facility, such as oscilloscopes, spectrum analyzers, and DVOMs. Many equipment manufacturers offer video programs that explain the operation of their products.

- *Basic Electronic Repair.* This 1988 program covers soldering and various types of equipment, including oscilloscopes. Could be used in this or the next unit. Available from: Cambridge Career Products; P.O. Box 2153, Dept, CC13; Charleston, WV 25328-2153; 800-468-4227.
- *Basic Electronic Test Instruments.* This three-tape series was released in 1987 and includes information on multimeters and oscilloscopes. Available from: Bergwall Productions, Inc.; P.O. Box 238; Garden City, NY 11530; 800-645-3565.
- *Chemical Safety.* This is a series of three videotapes dealing with chemicals in the workplace. The first program (20 minutes) covers safety rules and MSDSs. The second program (21 minutes) discusses how chemicals can enter the body and emphasizes the use of air filters and respirators. The last program (20 minutes) covers fires, explosions, and chemical reactions. Available from: Tel-A-Train; P.O. Box 4752; Chattanooga, TN 37405; 800-266-0113.

Suggested Activities

- *Electrical Lockout/Tagout.* This 28-minute program explains the principles of equipment and electrical circuit lockout and tagout. Available from: Tel-A-Train; P.O. Box 4752; Chattanooga, TN 37405; 800-266-0113.
- *Electrical Safety.* This program uses three case histories to discuss electrical hazards under 600 volts that electricians, equipment operators, and maintenance personnel are likely to encounter. The program is 29 minutes long. Available from: Tel-A-Train; P.O. Box 4752; Chattanooga, TN 37405; 800-266-0113.
- *Electrical Safety, Skin Protection, and Horseplay Hazards.* This 25-minute program is designed for company safety programs and covers the topics in the title. Available from: Coronet Films; 108 Wilmot Rd.; Deerfield, IL 60015.
- *Electrostatic Discharge.* For use with Objectives 4-6 in this unit, this program demonstrates how ESD can occur and how it can affect electronic components and assemblies. The videotape also talks about ways of preventing ESD damage. Available from: 3M, Static Control Systems Division; P.O. Drawer 2963; Bldg. 130-3N-46; Austin, TX 78769-2963.
- *The Path of Least Resistance.* This is a short (15-minute) program about how a person can become part of an electrical circuit in the home or the workplace. It emphasizes mistakes people often make involving electrical tools and appliances. Available from: Agency for Instructional Technology; Box A; Bloomington, IN 47402-0102; 800-457-4509.
- *Portable Fire Extinguishers.* This 26-minute program covers the four classes of fires and the extinguishers that can be used to fight them. Available from: Tel-A-Train; P.O. Box 4752; Chattanooga, TN 37405; 800-266-0113.
- *Power and Hand Tool Safety.* This is a general program about tool safety in the home and workplace, but it includes several of the tools covered in this unit. The program is 21 minutes long. Available from: Tel-A-Train; P.O. Box 4752; Chattanooga, TN 37405; 800-266-0113.
- *Safety on the Job: Fire Extinguishers.* This 23-minute program covers fire emergencies and discusses the four classes of fires and five extinguishing agents. Available from: Aims Instructional Media; 9710 DeSoto Ave.; Chatsworth, CA 91311-4409; 800-367-2467.

Suggested Activities

- *16 Leading Causes of OSHA Citations and How to Avoid Them.* This 20-minute program will acquaint students with safety regulations and OSHA inspections in support of Objective 27. Available from: Coronet Films; 108 Wilmot Rd.; Deerfield, IL 60015.

Shop Orientation and Safety
Unit 2

Answers to Assignment Sheets

Assignment Sheet 1—Interpret Material Safety Data Sheets

Note: Answers will depend on which MSDSs are used. The answers given below are for the sample MSDSs provided in Supplement 3.

MSDS 1

1. Pro-Tech cleaner
2. Ethanol
3. 1000 ppm
4. Yes (chlorinated hydrocarbons)
5. Irritation
6. May aggravate existing conditions
7. Asphyxia or pneumonia
8. Safety glasses and neoprene gloves recommended
9. Flush with water for 15 minutes and contact a physician
10. Wash with soap and water; contact a physician if rash or irritation develops
11. Aerosol cans may rupture at temperatures above 130°F
12. CO_2, foam
13. Yes
14. Carbon monoxide, carbon dioxide, hydrochloric acid, chlorine, and phosgene
15. Cool, dry place
16. Incinerate or landfill in accordance with applicable local, state, and federal regulations; do not flush into sewers

MSDS 2

1. ZAP Alkaline Battery
2. Potassium hydroxide (KOH)
3. Ceiling: 2 mg/m^3
4. None listed
5. KOH can cause permanent damage
6. KOH can cause burns
7. Gives off toxic vapors when heated
8. Neoprene, rubber, or latex nitrile gloves recommended when handling leaky batteries
9. Flush with water for 15 minutes and contact a physician
10. Wash thoroughly; contact a physician if blisters develop
11. Batteries may rupture when heated
12. CO_2, foam
13. Yes
14. Toxic vapors when heated
15. Dry place at less than 85°F

Answers to Assignment Sheets

16. Landfill in accordance with applicable local, state, and federal regulations; do not incinerate

Assignment Sheet 2—Interpret Safety Symbols and Colors

1. a
2. c
3. b
4. a
5. d
6. a
7. d
8. a
9. b
10. d

Assignment Sheet 3—Determine Basic First-Aid Measures for Emergency Situations

1. Cover it lightly with gauze.
2. Traumatic shock. Lay the victim down and elevate her legs slightly. Cover body to prevent loss of body heat.
3. Supervisor should take care of victim, administering CPR if necessary. One crew member should call for help while the other assists the supervisor as required.
4. Turn off power or use a nonconductor to separate the victim from the electrical source.
   One person should tend to the victim while the other requests medical assistance.
   Check the airway to see that it is open. Check to see that the victim is breathing. Check for a heartbeat and pulse and check for bleeding.
   Try to open the airway by moving the tongue out of the way.
   Elevate his feet. Keep him warm.
   Do not remove the wrench. Cover the burns with gauze or clean cloth.
   Try to keep him calm but do not allow him to move.
   Try to reduce the bleeding if it is life-threatening. Otherwise, leave it alone.
5. Assess the situation. Isolate the fire electrically if possible.
   Try to get her to drop and roll and calm down. If she does not, try wrapping her in a blanket, rug, or something that will smother the fire.
   Yes. Follow the PASS method.
   Cover the burns with gauze.

Assignment Sheet 4—Interpret Meter Readings

1. 3 volts
2. 6 volts
3. 125 volts
4. 20 volts
5. 5 mA

Answers to Assignment Sheets

6. 100 mA
7. 8 mA
8. 25 μA
9. 1.576 volts
10. 158 mA

Assignment Sheet 5—Calculate Voltage from Sine Wave Dimensions

1. 56.56 volts rms
2. 0.0707 volts rms
3. 10.605 volts rms
4. 28.28 volts rms

Assignment Sheet 6—Calculate Time and Frequency from Waveform Dimensions

1. 8 μs; 0.125 MHz
2. 8 ms; 0.125 KHz
3. 3 seconds; 0.33 Hz
4. 0.8 ms; 1.25 KHz

Assignment Sheet 7—Determine Phase Relationships of AC Signals

1. 90°
2. 135°
3. 90°
4. 135°
5. 180°
6. 90°

Shop Orientation and Safety
Unit 2

Answers to Written Test

1.	a.	15	g.	8	m.	17	s.	11
	b.	3	h.	6	n.	7	t.	21
	c.	10	i.	1	o.	2	u.	12
	d.	14	j.	16	p.	23	v.	19
	e.	5	k.	18	q.	4	w.	13
	f.	24	l.	20	r.	22	x.	9

2. a. Light
   b. Overhead rack
   c. Drawing clips
   d. Power strip
   e. Soldering iron
   f. ESD mat
   g. Work surface
   h. Drawers
   i. Conductive chair
   j. Grounding strap
   k. Conductive flooring

3.	a.	4	d.	5	g.	3	j.	2
	b.	6	e.	8	h.	11	k.	1
	c.	9	f.	10	i.	7		

4. a. Opens—Breaks in conductors
   b. Shorts—Melting of conductors that allow them to contact other conductors
   c. Destruction of components—Miniaturized components internal to parts and circuit boards are destroyed (burned or melted)
   d. Burn holes—Portions of the exterior shell of a part or circuit board are penetrated by a hole that exposes the internal components to the outside environment
   e. Degradation—Parts remain functional but may not operate across their full range or may fail sooner that is expected

5. a. Low humidity
   b. Moving air
   c. Certain materials

6.	a.	5	d.	1	g.	4
	b.	7	e.	3		
	c.	2	f.	6		

7. a. Long nose pliers
   b. Diagonal cutting pliers

Answers to Written Test

c. Lineman's side cutting pliers
d. Combination slip-joint pliers
e. Hacksaw
f. Hole saw
g. Flat-blade (slot-head) screwdriver
h. Phillips® head (cross-point) screwdriver
i. Torx® (star fastener) driver
j. Pozidriv® driver
k. Hex and spline (Allen) wrench
l. Adjustable wrench
m. Open-end wrench
n. Nut driver
o. Hemostat clamp
p. Ball peen hammer
q. Flat file
r. Half-round file
s. Precision files
t. Center punch
u. Square-hole punch
v. Round-hole punch
w. Drill and drill bits
x. Rivet gun
y. Box-end wrench

8.	a.	13	f.	15	k.	2	p.	4
	b.	14	g.	9	l.	7	q.	8
	c.	16	h.	1	m.	3		
	d.	12	i.	11	n.	6		
	e.	10	j.	5	o.	17		

9.	a.	2	d.	5	g.	7
	b.	1	e.	6	h.	3
	c.	8	f.	9	i.	4

10.	a.	3	d.	4	g.	1	j.	10
	b.	5	e.	9	h.	2	k.	8
	c.	7	f.	6	i.	11		

11.	a.	2	e.	7
	b.	1	f.	3
	c.	4	g.	6
	d.	8	h.	5

Answers to Written Test

12.

a.	14	f.	4	k.	6	p.	16
b.	12	g.	3	l.	7		
c.	1	h.	13	m.	15		
d.	8	i.	10	n.	2		
e.	5	j.	9	o.	11		

13. a. 2
b. 4
c. 1
d. 3

14. a 3
b. 4
c. 1
d. 2
e. 5

15. a. series
b. current
c. shunt

16. a. parallel
b. parallel, high
c. polarity
d. current
e. reciprocal
f. voltage
g. multiplier

17. a. battery
b. power
c. voltage
d. resistance
e. series, resistance
f. parallel, voltage

18. a. Digital meters provide the same functions as analog meters but use digital circuitry and displays.
b. The digital circuitry consists of four functional blocks: a signal processor, an analog to digital converter, a control unit, and a digital readout.
c. Most digital meters automatically adjust their range and select the correct polarity.

Answers to Written Test

19.

a.	8	e.	12	i.	3	m.	11
b.	6	f.	4	j.	9	n.	2
c.	5	g.	15	k.	10	o.	14
d.	7	h.	13	l.	1		

20.
a. chassis
b. way
c. horizontal amplifier
d. sweep generator
e. cathode ray tube
f. electron gun
g. phosphor
h. electrons
i. electron
j. position

21. b, c, e, f, g, h

22.
a. Peak-to-peak amplitude
b. Zero-to-peak amplitude
c. Leading edge
d. Positive peak
e. Trailing edge
f. Positive half cycle
g. Negative half cycle
h. Negative peak
i. Zero level

23.

a.	4	d.	1	g.	5	j.	3
b.	8	e.	7	h.	10		
c.	9	f.	2	i.	6		

24.
a. Electrical shock—Condition that results from electrical current entering the body that can lead to burns, muscle damage, or death as a result of the heart stopping or disruption of the nervous system
b. Burns—Damage to the skin, muscles, or organs as the result of exposure to high temperatures, high intensity lights, electrical shock, radiation, or chemicals
c. Electrical fires—Burning of electrical components and devices that can cause property damage or injury as a result of the fire or through the production of poisonous gases and smoke
d. Chemical poisoning—Condition in which substances enter the body and interfere with its normal functioning
e. Cuts and abrasions—Bodily injuries that generally result from the improper use of tools or flying debris, such as wire and lead clippings
f. High energy exposure—Injuries that result from being exposed to high intensity light such as lasers (blindness and burns), high-frequency sound waves

Answers to Written Test

(temporary or permanent deafness), microwaves (bone and joint damage and burns), or radiation (burns, radiation sickness, genetic deformities in offspring)

25.
- a. Keep all tools clean and in good working order.
- b. Do not remove safety devices, such as guards, grounding straps, switch covers, without permission of your instructor.
- c. Keep the workplace clean and orderly; dispose of all litter and clean up spills immediately.
- d. Do not leave power equipment unattended.
- e. Isolate power voltages from ground by means of isolation transformers.
- f. Store chemicals in suitable containers in proper storage areas.
- g. If you must use chemicals in the work area, take only as much as you think that you will need to do the job.

26.

a.	all	f.	MSDS
b.	minor	g.	rings, watches, jewelry
c.	instruction	h.	horseplay, practical jokes
d.	conductors	i.	safety glasses
e.	30		

27. b, d, e

28.

a.	3	f.	5	k.	4	p.	7
b.	1	g.	6	l.	1	q.	7
c.	2	h.	4	m.	7		
d.	7	i.	6	n.	6		
e.	1	j.	3	o.	6		

29.
- a. Live circuits—Work with electronic circuitry requires that those circuits sometimes be powered during testing and maintenance.
- b. Exposed conductors—Although most conductors are insulated, terminals, connectors, and other components may have uninsulated conductors.
- c. Capacitive components—Some electrical and electronic components store charge which can cause shock even when the equipment is not powered.
- d. Accidental circuits—Circuits can be created through improper fabrication or maintenance or as the result of shorts and grounds that can energize conductors and components that the technician does not expect to be energized.

30.
- a. conductor
- b. voltage, current, resistance, exposure, site, differences
- c. voltage
- d. current

31.
- a. Remove the victim from the source of shock.
- b. Call for assistance.
- c. Administer resuscitation if required and if properly trained.

Answers to Written Test

d. Administer first-aid for traumatic shock by keeping the victim warm and comfortable and elevating the legs slightly.

e. Take precautions to protect burns by covering them lightly with sterile gauze if available or with clean cloths.

f. Continue to provide attention to the victim until professional medical assistance is available.

32. a. 2
    b. 1
    c. 3
    d. 4
    e. 6
    f. 5

33. a. Ingestion—By mouth
    b. Absorption—Through the skin
    c. Inhalation—By breathing in vapors, gases, or fumes

34. a. 3
    b. 1
    c. 4
    d. 2

35. a. High-intensity light—Can cause temporary or permanent blindness or burns from the heat produced
    b. High-intensity sound waves—Can cause temporary or permanent deafness
    c. Electromagnetic waves—Can interfere with pace-makers and can lead to excessive vibration and heating of internal organs
    d. Radiation waves and particles—Can cause burns and can lead to cancer and genetic defects in the offspring of victims

Shop Orientation and Safety
Unit 2

Written Test

Name ______________________________ Date ____________ Score ____________

1. Match terms associated with shop orientation and safety to their correct definitions. Write the corresponding numbers on the blanks provided.

______a. Form that lists and explains each of the hazardous materials that an employee works with so that the employee can safely use the material and respond to emergency situations

______b. One complete reversal of an alternating current from negative to positive and back to negative or other sequence of a complete return to a beginning point

______c. Grid lines marking the screen of an oscilloscope, generally in 1-centimeter squares

______d. An atom or group of atoms that carries either a negative or positive charge

______e. To remove

______f. Shape of a trace

______g. Capable of being ignited and burning quickly

______h. Device used to mechanically join parts

______i. Process of adjusting test and measurement equipment to a known standard to ensure that the device is accurate

______j. Substance that illuminates when bombarded with electrons

______k. Process of joining parts by coating them with a melted alloy of tin and lead and allowing it to harden

1. Calibration
2. Crimping
3. Cycle
4. Electrostatic discharge
5. Extract
6. Fastener
7. First aid
8. Flammable
9. Frequency
10. Graticule
11. Humidity
12. Insert
13. Inspection
14. Ion
15. Material Safety Data Sheet
16. Phosphor
17. Shunt
18. Soldering

Written Test

______l. To remove insulation from wire or cable

______m. Circuit that is wired in parallel with another circuit

______n. Immediate temporary care given the victim of an accident or sudden illness until the services of a physician can be obtained

______o. Method of installing an electrical connector on a conductor by deforming it under pressure

______p. Pattern representing signal as displayed on an oscilloscope

______q. Transfer of electrical charge as a result of static electricity from one object to another

______r. To coat an exposed conductor with solder to protect it from corrosion or to improve solderability

______s. Amount of moisture in the air in the form of water vapor

______t. To exercise an electrical circuit or device to verify that it is functioning correctly, often while using special equipment to measure its performance

______u. To install a part or assembly into a hole or receptacle intended to receive the part or assembly

______v. Electrical charge that builds up on objects as result of the object moving through the air or moving against certain materials such as plastics

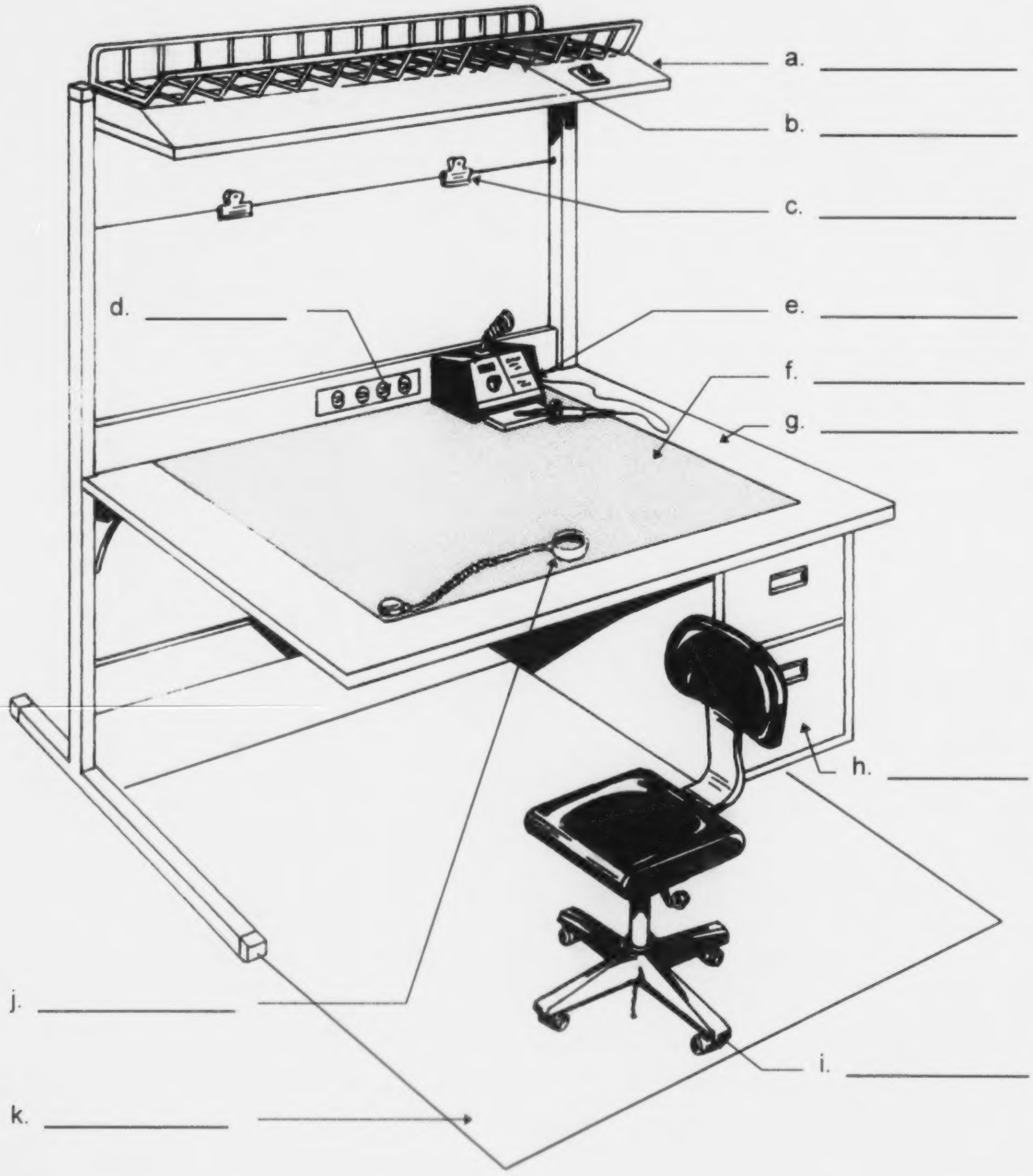
______w. Act of examining a part or assembly visually in an effort to identify defects

______x. Number of cycles per second for a signal as measured in hertz (Hz)

19. Static electricity
20. Strip
21. Test
22. Tin
23. Trace
24. Waveform

Written Test

2. Label the parts of a typical electronics workstation.



Written Test

3. Match parts of a typical electronics work station to their correct functions. Write the corresponding numbers on the blanks provided.

______a. Helps maintain work, worker, and work area at the same potential difference

______b. Connects worker to ESD mat with an electrically conductive pathway

______c. Provides several electrical outlets for tools and test equipment

______d. Provides seat for worker and conductive pathway to floor

______e. Provides additional storage space for small, light objects

______f. Provides heat source for melting solder for parts assembly

______g. Holds drawings up for viewing and off the work area

______h. Provides area on which work is done

______i. Provides illumination for work area

______j. Holds tools and supplies

______k. Provides a conductive path to the whole work area and often to an earth ground

1. Conductive flooring
2. Drawers
3. Drawing clips
4. Electrostatic discharge mat
5. Conductive chair
6. Grounding strap
7. Light
8. Overhead rack
9. Power strip
10. Soldering iron
11. Work surface

4. List types of damage that can occur to electrostatic-sensitive devices.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

Written Test

5. List conditions that promote electrostatic discharge.

a. ____

b. ____

c. ____

6. Match methods for reducing and monitoring electrostatic discharge to their correct descriptions. Write the corresponding numbers on the blanks provided.

______a. Devices that add moisture to the air to maintain the humidity in the work area within an acceptable range, such as 30 to 70 percent

______b. Chemicals that can be used to reduce the amount of static buildup where other measures are not practical

______c. Surfaces that conduct excess charge from objects and personnel in contact with them to help reduce the buildup of electrical charge

______d. Electronic devices that reduce the number of free electrons in the air immediately around a work area to reduce the buildup of static electricity

______e. Devices that activate an alarm when a discharge event of a certain level has occurred

______f. Elastic bands, generally used on the wrist or foot, with an internal resistor that helps conduct static charge away from a person's body to minimize the potential difference in the charge of personnel and the area with which they have contact through the band or a conductive cord attached to the band

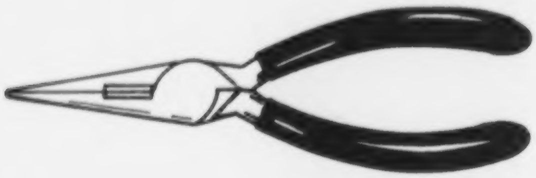
______g. Boxes, bags, plastic sleeves, etc. Used to store and carry ESD-sensitive parts and components that reduce the risk of damage either by being conductive or by the use of materials that reduce the buildup of static

1. Air ionizers
2. Conductive surfaces
3. Electronic monitors
4. ESD containers
5. Humidifiers
6. Personal straps
7. Static sprays

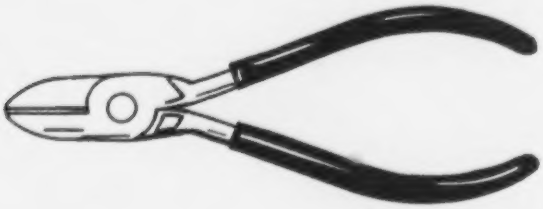
Written Test

7. Identify types of general hand tools used in the electronics workplace.

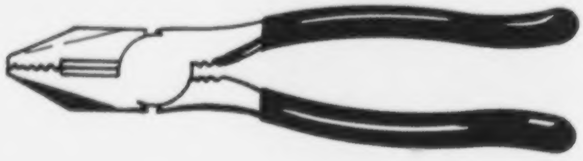
a. ______________________________



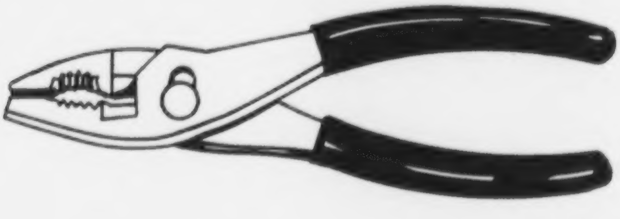
b. ______________________________



c. ______________________________

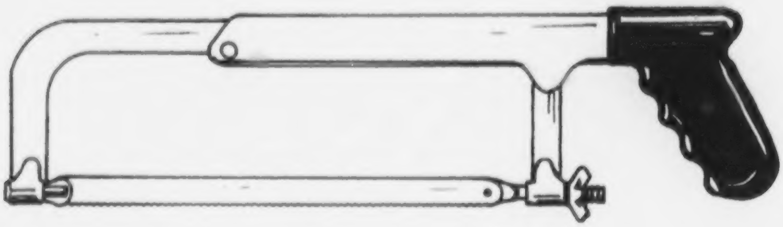


d. ______________________________

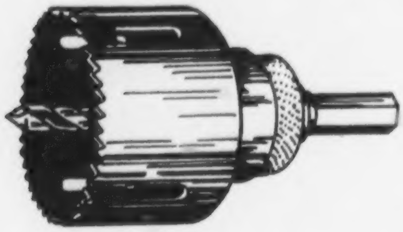


Written Test

e. ____________________

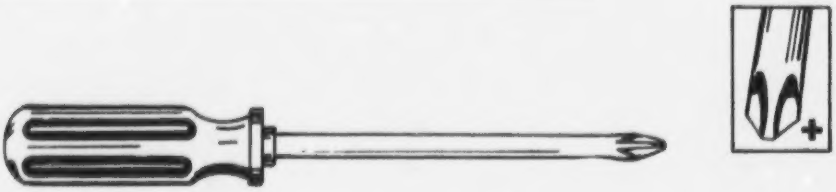


f. ____________________



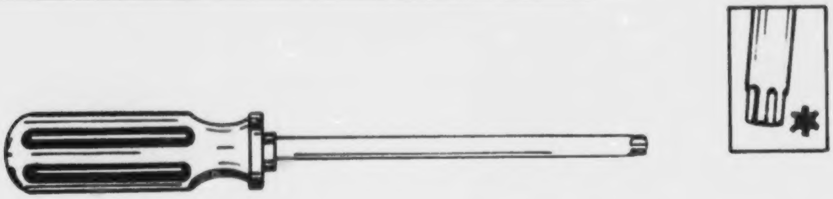
g. ____________________

h. ____________________

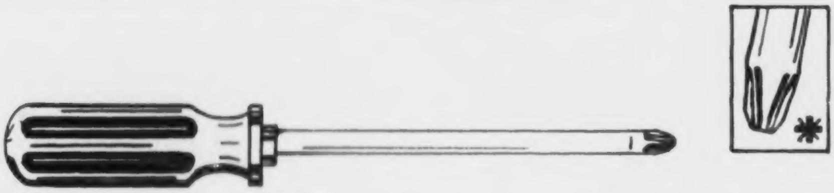


Written Test

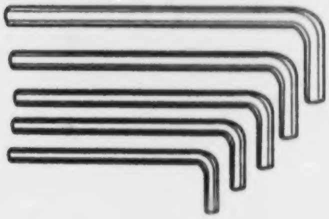
i. ______________________________



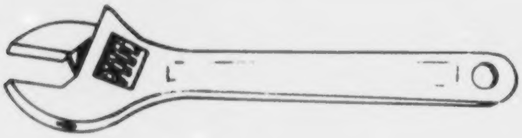
j. ______________________________



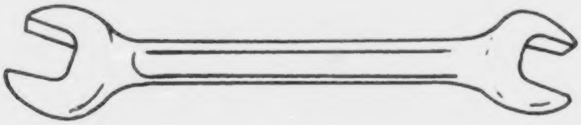
k. ______________________________



l. ______________________________

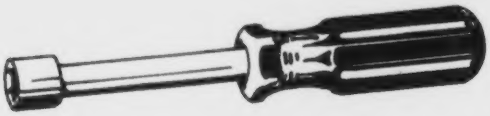


m. ______________________________

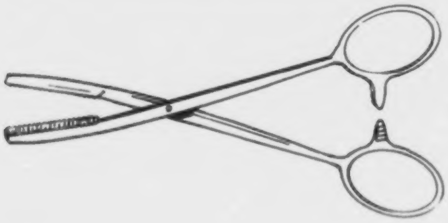


Written Test

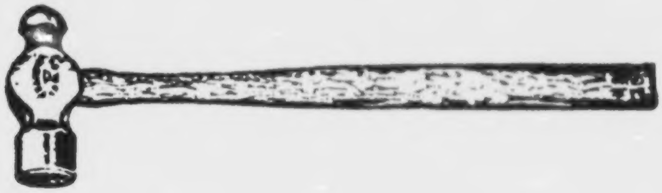
n. ______________________________



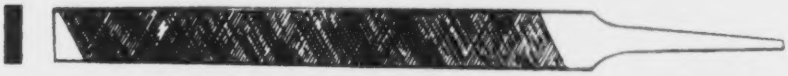
o. ______________________________



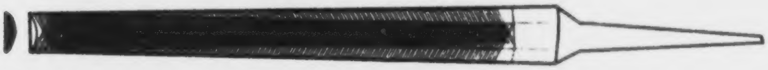
p. ______________________________



q. ______________________________

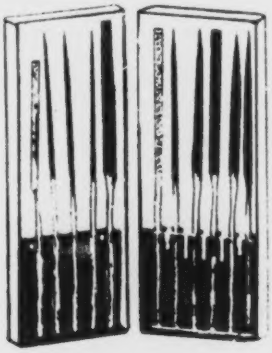


r. ______________________________

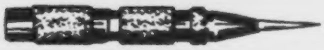


Written Test

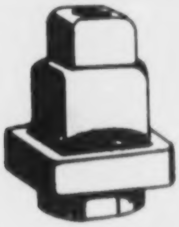
s. ______________________________



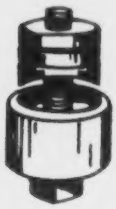
t. ______________________________



u. ______________________________

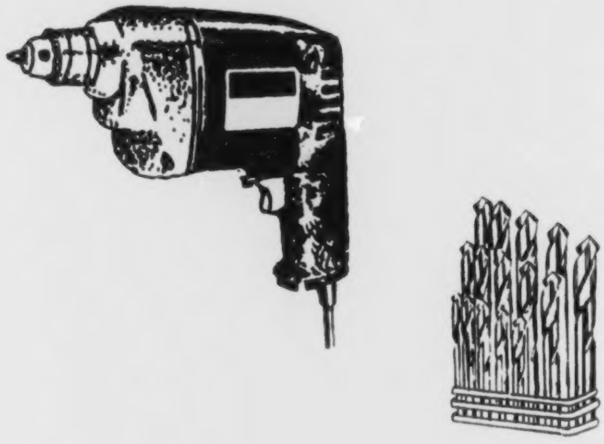


v. ______________________________

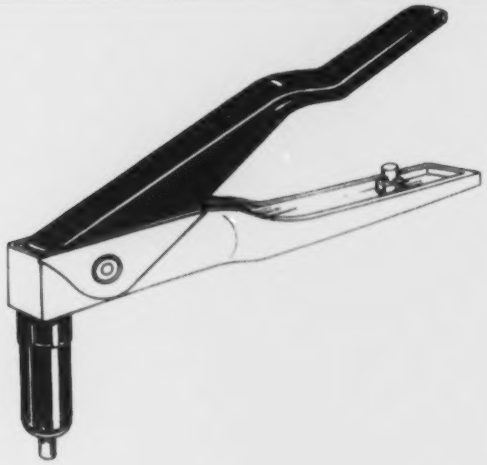


Written Test

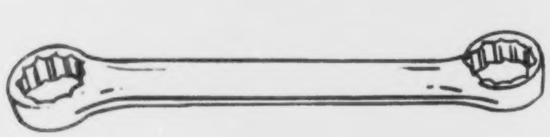
w. ______________________________



x. ______________________________



y. ______________________________



Written Test

8. Match general hand tools to their correct uses in the electronics workplace. Write the corresponding numbers on the blanks provided.

______a. Holding components and parts; shaping and forming small conductors and component leads; reaching into tight areas

______b. Tightening, loosening, and holding light-duty nuts and bolts

______c. Making holes or indentations of specific shapes; installing or removing pins and removing rivets

______d. Cutting heavy conductors and cables and small metal parts; stripping insulation from wires; forming heavy conductors

______e. Installing or removing threaded fasteners such as socket cap screws and set screws with hex slots

______f. Finishing small metal surfaces such as small drill holes and some solder joints

______g. Holding wires and small parts

______h. Driving punches; installing and removing some types of fasteners

______i. Cutting large holes

______j. Installing or removing threaded fasteners with specific head designs

______k. Holding or turning components and parts; forming heavy conductors

______l. Cutting fasteners and metal parts

______m. Cutting wire and component leads; stripping insulation from wire

______n. Removing rough edges on cut metal straight edges

1. Ball peen hammer
2. Combination slip-joint pliers
3. Diagonal cutting pliers
4. Drill and drill bits
5. Fastener drivers
6. Flat file
7. Hacksaw
8. Half-round file
9. Hemostat clamp
10. Hex and spline wrench
11. Hole saw
12. Lineman's side-cutting pliers
13. Long nose pliers
14. Nut driver
15. Precision file
16. Punches
17. Wrenches

Written Test

______o. Tightening, loosening, or holding nuts and bolts

______p. Making holes; tightening or loosening threaded fasteners

______q. Removing rough edges on large cut metal holes

9. Match wire preparation and assembly tools to their correct uses. Write the corresponding numbers on the blanks provided.

______a. Cutting wire, stripping insulation from wire, measuring strip lengths; also provides crimping, bolt cutting, and thread gauge capabilities

______b. Compressing the barrels of sleeve-type connectors to create a mechanical bond with a wire

______c. Cutting and removing insulation from cables; separating cable strands

______d. Installing and removing pins in or from connector bodies

______e. Removing insulation automatically with precise settings

______f. Measuring wire diameters

______g. Removing insulation with heat

______h. Shrinking heat shrink tubing

______i. Removing insulation from wire by hand

1. Crimping tool
2. Electrician's six-in-one tool
3. Heat gun
4. Mechanical wire stripper
5. Pin insertion and removal tools
6. Programmable wire stripper
7. Thermal wire stripper
8. Utility knife
9. Wire gauge

10. Match soldering tools to their correct uses. Write the corresponding numbers on the blanks provided. Write the corresponding numbers on the blanks provided.

______a. Hand soldering of components where precise temperature and power controls are required or preferred

1. Circuit board vise
2. Desoldering bulb

______b. Providing a source of heat so that soldering or desoldering temperatures are not dissipated as quickly

______c. Hand soldering where low power outputs are acceptable

______d. Increasing the thermal mass of a connection to be soldered so that the component does not get exposed to as much heat

______e. Removing excess solder or desoldering connections through suction created by a spring-loaded piston

______f. Installing surface-mount components

______g. Holding circuit boards and other assemblies so that they can be soldered or otherwise worked on

______h. Removing excess solder or desoldering connections through suction created by manually squeezing a rubber bulb

______i. Soldering entire circuit boards by running them across a vat of solder in which a wave has been produced

______j. Removing excess solder from a connection

______k. Hand soldering in a medium power and temperature range, especially where less precise solder joints are involved

3. Hand soldering machine
4. Heat sink
5. Hot plate
6. Reflow equipment
7. Soldering iron and stand
8. Soldering gun and stand
9. Solder sucker
10. Solder wick
11. Wave soldering machine

11. Match electronic component handling and preparation tools to their correct uses. Write the corresponding numbers on the blanks provided.

______a. Removing components

______b. Cleaning components and assemblies with water-based solutions

______c. Removing oxidation and contaminants from component leads

1. Aqueous cleaner
2. Component extraction tools
3. Component insertion tools

Written Test

______d. Cleaning components and assemblies with solvents

______e. Applying a thin layer of solder on component leads to protect them from oxidation and to improve solderability

______f. Holding components for installation

______g. Shaping leads one at a time

______h. Shaping the leads on multiple-lead components

4. Component lead cleaner
5. Lead-forming dies
6. Lead-forming tools
7. Tinning equipment
8. Vapor degreaser

12. Match types of electronic test equipment and inspection tools to their correct uses. Write the corresponding numbers on the blanks provided.

______a. Providing controlled levels of voltage

______b. Comparing an assembly to a standard assembly to determine differences between the two

______c. Testing the functionality of circuit boards and other assemblies

______d. Providing AC from a source that is electrically isolated from utility power

______e. Measuring the output of wires and conductors in a cable to ensure continuity

______f. Testing specific types of components such as transistors and diodes

______g. Measuring the amount of contaminants on a component or circuit board

______h. Displaying representations of voltage against time

______i. Identifying logic levels in digital circuits

1. Bead-of-nails tester
2. Bridge
3. Cleanliness tester
4. Component testers
5. Continuity tester
6. Function generator
7. Inspection scope
8. Isolation transformer
9. Logic clip
10. Logic probe
11. Logic pulser
12. Optical comparator
13. Oscilloscope

______j. Identifying logic levels of an integrated circuit over which it fits

______k. Providing a voltage source with various known waveforms

______l. Magnifying assemblies and components for visual inspection

______m. Providing signal outputs, such as audio waveforms

______n. Measuring electrical characteristics at very precise levels

______o. Injecting short bursts of signals into digital circuits

______p. Inspecting conformal coating on circuit boards

14. Power supply
15. Signal generator
16. Ultraviolet inspection light

13. Match types of meters to their correct descriptions. Write the corresponding numbers on the blanks provided.

______a. Measuring various electrical characteristics

______b. Measuring voltage or current

______c. Measuring current

______d. Measuring resistance or voltage

1. Ammeter
2. Multimeter
3. Ohmmeter
4. Voltmeter

14. Match types of analog meter movements to their correct descriptions. Write the corresponding numbers on the blanks provided.

______a. Polarity-sensitive DC meter movement produced with a horseshoe magnet, soft-iron core, and movable coil

______b. DC meter movement with a horseshoe magnet and an iron core attached to two tightly stretched metal ribbons to reduce friction and provide greater sensitivity in meter movements

1. Electrodynamometer
2. Iron vane
3. Moving coil (D'Arsonval)
4. Taut-band
5. Thermocouple

______c. DC and low frequency AC meter movement that uses two stationary coils in place of a magnet; provides low sensitivity

______d. Low frequency AC meter movement that uses an iron core inside a stationary coil that acts like a plunger to cause needle movement

______e. Wide-range AC meter movement whose moving coil is connected to a heat-sensitive device to provide more accurate readings

15. Complete statements about the characteristics and operation of an ammeter.

    a. Ammeters are connected in ______________ with the circuit being tested.

    b. The sensitivity of an ammeter is the amount of ______________ required to cause full-scale deflection of the pointer.

    c. The full-scale range of the ammeter can be extended through the use of a ______________ resistor in parallel with the meter movement.

16. Complete statements about the characteristics and operation of a voltmeter.

    a. Voltmeters are connected in ______________ with the circuit being tested.

    b. Because the voltmeter is connected in ____________ to the circuit, the meter resistance affects the circuit measurement and, therefore, should be very ______________.

    c. ______________ must be observed when using a voltmeter.

    d. Voltmeters can be used to measure either voltage or ______________.

    e. The sensitivity of a voltmeter is the ______________ of the full-scale current range and is expressed as *ohms/volt*.

f. Many voltmeters have internal circuits that allow .selection of different ________________ ranges.

g. The full-scale voltage range of the voltmeter can be extended through the use of a ________________ resistor connected in series with the meter movement.

17. Complete statements about the characteristics and operation of an ohmmeter.

a. The ohmmeter contains a ________________ power source that replaces the power source portion of the circuit.

b. ________________ must be removed from the circuit before using an ohmmeter.

c. Ohmmeters can be used to measure either resistance or ________________.

d. Many ohmmeters use multiplier resistors and shunt resistors to provide multiple ________________ ranges.

e. The multiplier resistors are used to connect the meter in ________________ with the circuit and measure ________________.

f. The shunt resistors are used to connect the meter in ________________ with the circuit to measure ________________.

18. Describe the operation of a digital meter. For each key word or phrase below, describe how that word or phrase applies to the operation of a digital meter.

a. Functions— ____

____

b. Functional blocks—____

____

c. Range and polarity adjustment— ____

____

Written Test

19. Match oscilloscope controls to their correct functions. Write the corresponding numbers on the blanks provided.

______a. Adjusts image brightness

______b. Adjusts image clarity and sharpness of waveform presentation

______c. Provides for the input of an external voltage to be used as the trigger initiates the sweep

______d. Moves image to the left or right on the display

______e. Selects channel to be displayed

______f. Provides for an external input to allow control of the horizontal sweep by an external signal

______g. Adjusts the image up and down on the display

______h. Selects voltage level of the triggering waveform that initiates the sweep

______i. Selects between AC and DC inputs

______j. Turns oscilloscope on and off

______k. Overlays the graticule on the display

______l. Provides signal to allow the oscilloscope to self-adjust for accurate measurements

______m. Selects rate of horizontal movement across display

______n. Provides connections of input voltages to each of the two channels

______o. Selects the signal to initiate the sweep

1. Calibration control
2. Channel A and Channel B input
3. Coupling control
4. External horizontal input
5. External trigger
6. Focus control
7. Horizontal position control
8. Intensity control
9. Power switch
10. Scale illumination switch
11. Sweep control
12. Sweep mode control
13. Trigger level control
14. Trigger source control
15. Vertical position control

20. Complete statements regarding the operation of an oscilloscope.

    a. An oscilloscope consists of a ____________ that contains processing circuitry, a control panel, a connector panel, and a display.

    b. The processing circuitry provides control over the __________ signals are displayed.

    c. The ____________________ allows an external input to be displayed on the horizontal axis and amplifies the signal from the sweep generator.

    d. The ____________________ produces a horizontal trace across the screen.

    e. Most oscilloscopes use a ____________________ (CRT) display.

    f. An ____________________ at the rear of the CRT sends a fine beam of electrons that duplicates the waveform of the input signal.

    g. The electrons strike a ______________ coating on the screen of the display.

    h. The phosphors glow when struck by _______________, transmitting light through the display glass.

    i. Electrostatic plates deflect the _______________ beam to position where it hits the screen.

    j. The electrostatic plates are adjustable to change the _______________ of the image on the screen, with a set of two plates providing vertical adjustment and a second set of plates providing horizontal adjustment.

21. Select from a list measurements that can be made with an oscilloscope. Write an "X" beside each item listed below that is a measurement that can be made with an oscilloscope.

    ______a. Shape of a current waveform

    ______b. Shape of a voltage waveform

    ______c. Phasing of waveforms

    ______d. Total circuit resistance

    ______e. Frequency of waveforms

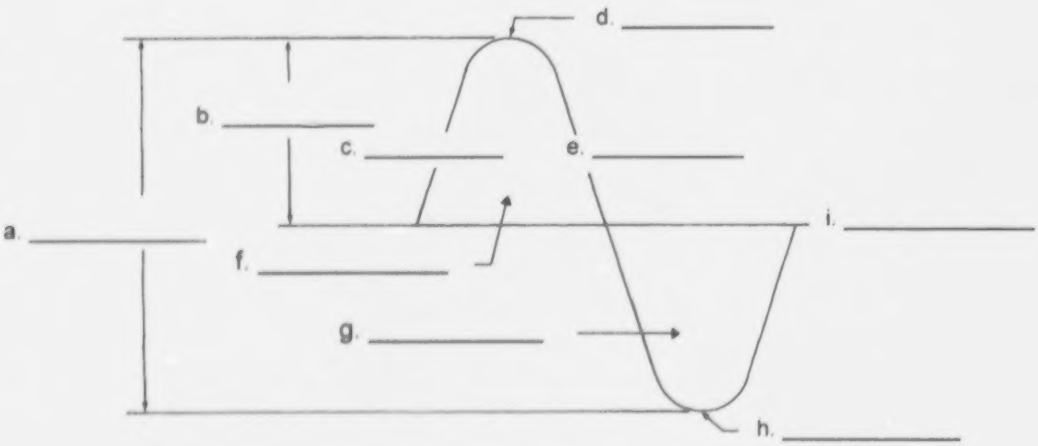
    ______f. Total voltage

Written Test

______g. Peak voltage

______h. Peak-to-peak voltage

22. Label the parts of a waveform display.



23. Match chemicals used in the electronics workplace to their correct applications. Write the corresponding numbers on the blanks provided.

______a. Used to clean metal

______b. Used to thin lacquer and ink

______c. Used as a general purpose cleaner and in vapor degreasers

______d. Used to remove oils, grease, paint, and lacquer

______e. Used to thin lacquer and paint

______f. Used to cover circuit boards to protect them from moisture

______g. Used to label parts and circuit board locations

______h. Used to fill in connector bodies

1. Acetone
2. Conformal coating
3. Ethyl alcohol
4. Hydrochloric acid
5. Inks
6. Isopropyl alcohol
7. Ketone
8. Lacquer thinner
9. Perchlorethylene
10. Potting compound

Written Test

______ i. Used to remove oil, grease, and flux

______ j. Used to clean solder connections and to thin rosin

24. Describe types of hazards that may be encountered in an electronics shop. For each key word or phrase below, describe how that word or phrase applies to types of hazards that may be encountered in an electronics shop.

a. Electrical shock—______________________________

b. Burns—______________________________

c. Electrical fires—______________________________

d. Chemical poisoning—______________________________

e. Cuts and abrasions—______________________________

f. High energy exposure—______________________________

25. State rules for maintaining a safe work area. For each word or phrase below, state a rule for maintaining a safe work area that is related to that word or phrase.

a. Tools—______________________________

b. Safety devices—______________________________

c. Cleanliness—____

____

d. Power equipment—____

____

e. Isolating power voltages—____

____

f. Chemical storage—____

____

g. Chemicals in the work area—____

____

26. Complete statements regarding general workplace safety.

a. Report ______________ tool defects and safety problems to your instructor.

b. Report all accidents to your instructor regardless of how ______________ they may seem.

c. Do not energize or operate any equipment without first receiving ______________ on its safe operation.

d. When measuring voltages, be careful not to come into contact with any ______________.

e. If a voltage is expected to exceed ______________ volts, turn off or disconnect the equipment prior to connecting test equipment.

f. Do not use any solvents, paints, lacquers, or other chemicals without first reviewing the ______________ or receiving instruction on the use of the substance.

g. Do not wear ______________, ______________, or ______________ when working with electrical or electronic equipment.

h. Do not engage in ______________ or ______________ in the work area.

i. Wear appropriate clothing, including ______________ when required.

27. Select from a list roles of agencies involved in overseeing safety and public safety in the electronics workplace. Write an "X" beside each item listed below that is a correct listing of an agency and its role in overseeing safety and public safety in the electronics workplace.

______a. Insurance Underwriters—Conducts testing to determine the degree of safety designed and built into electrical and other devices

______b. Occupational Safety and Health Agency—Is responsible for ensuring compliance with federal legislation governing safe and healthful working conditions for employees

______c. Environmental Hazards Administration—Oversees the use of and proper disposal of chemicals and other products that might present health or environmental hazards

______d. Environmental Protection Agency—Oversees the use of and proper disposal of chemicals and other products that might present health or environmental hazards

______e. Underwriters Laboratories—Conducts testing to determine the degree of safety designed and built into electrical and other devices

______f. Department of Safety and Health—Is responsible for ensuring compliance with federal legislation governing safe and healthful working conditions for employees

28. Match safety code colors to their correct meanings. Write the corresponding numbers on the blanks provided. Each answer may be used more than once.

______a. Identifies safety equipment other than fire-fighting equipment and its location

______b. Indicate traffic-flow paths

______c. Identifies tags that indicate equipment that should not be started, used, or moved

______d. Indicates waste containers for explosive or combustible materials

1. Federal safety black and white
2. Federal safety blue
3. Federal safety green
4. Federal safety orange

_____e. Identify housekeeping equipment and its location

_____f. Indicates radiation hazards

_____g. Identifies emergency stop bars, stop buttons, and electrical stop switches on machinery

_____h. Identifies dangerous parts of equipment that could cut, crush, shock, or otherwise injure

_____i. Indicates danger

_____j. Identifies first-aid equipment and its location

_____k. Identifies safety starter buttons

_____l. Indicate storage areas

_____m. Indicates caution and marks physical hazards

_____n. Identifies portable containers for explosive or flammable liquids

_____o. Indicates fire-protection equipment and its location

_____p. Identifies the starting point or power source for machinery

_____q. Indicates equipment that should not be started, used, or moved

5. Federal safety purple
6. Federal safety red
7. Federal safety yellow

29. Describe electrical hazards in the electronics workplace. For each key word or phrase below, describe how that word or phrase applies to electrical hazards in the electronics workplace.

    a. Live circuits—____

    ____

b. Exposed conductors—____

____

c. Capacitive components—____

____

d. Accidental circuits—____

____

30. Complete statements about electrical shock.

a. Electrical shock is the result of the human body becoming a ________________ for electricity.

b. Six major variables affect the damage that can occur as a result of electrical shock:

- The amount of ________________
- The amount of ________________
- The body's level of electrical ________________
- The amount of time of ________________
- The entry ________________
- Individual ________________ in people

c. High ________________ tends to knock the victim away from the circuit, reducing the time of exposure.

d. High ________________ tends to paralyze the muscles, causing the victim to remain in contact with the circuit.

Written Test

31. List the steps in treating victims of electrical shock.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

32. Match chemical hazards in the electronics workplace to their correct descriptions. Write the corresponding numbers on the blanks provided.

______a. Cause burns upon contact with the skin or body parts

______b. Cause cancer, usually after long-term or excessive exposures

______c. Cause death or destruction of organs within a short time after exposure

______d. Cause watery eyes, itchy skin, sneezing, or similar conditions that are not injurious but which may present safety hazards by being a distraction

______e. May cause birth defects in the children of those suffering exposure

______f. Cause death or destruction of organs after frequent exposure over a period of time

1. Carcinogens
2. Caustics
3. Immediate toxins
4. Irritants
5. Long-term toxins
6. Mutagens

33. List ways in which chemicals can enter the body.

a. ______________________________

b. ______________________________

c. ______________________________

Written Test

34. Match classes of fires to their correct descriptions. Write the corresponding numbers on the blanks provided.

______a. Live electrical equipment, such as computers, test equipment, electronic devices, and electrical wiring

______b. Ordinary combustible materials such as paper, wood, rags, and plastics

______c. Combustible metals such as iron, magnesium, sodium, and potassium

______d. Flammable liquids and gases such as solvents, oil, paints, and inks

1. Class A
2. Class B
3. Class C
4. Class D

35. Describe high energy hazards in the electronics workplace. For each key word or phrase below, describe how that word or phrase applies to high energy hazards in the electronics workplace.

a. High-intensity light—______________________________

____

b. High-intensity sound waves—______________________________

____

c. Electromagnetic waves—______________________________

____

d. Radiation waves and particles—______________________________

____

*Permission to duplicate this test is granted.

Shop Orientation and Safety
Unit 2

Unit Evaluation Form

Student Name ______________________________ Unit Rating ______________

Assignment Sheet Ratings

Assignment Sheet 1—Interpret Material Safety Data Sheets Rating _____

Comments: ____

____

Assignment Sheet 2—Interpret Safety Symbols and Colors Rating _____

Comments: ____

____

Assignment Sheet 3—Determine Basic First-Aid Measures for Emergency Situations Rating _____

Comments: ____

____

Assignment Sheet 4—Interpret Meter Readings Rating _____

Comments: ____

____

Assignment Sheet 5—Calculate Voltage from Sine Wave Dimensions Rating _____

Comments: ____

____

Assignment Sheet 6—Calculate Time and Frequency from Waveform Dimensions Rating _____

Comments: ____

____

Unit Evaluation Form

Assignment Sheet 7—Determine Phase Relationships of AC Signals Rating _____

Comments: ____

____

Job Sheet Ratings

Job Sheet 1—Lift and Move a Heavy Object Rating _____

Comments: ____

____

Job Sheet 2—Operate a Fire Extinguisher Rating _____

Comments: ____

____

Job Sheet 3—Handle and Store Flammable Materials and Toxic Substances Rating _____

Comments: ____

____

Job Sheet 4—Obtain Tools from the Tool Crib Rating _____

Comments: ____

____

Job Sheet 5—Measure Electrical Characteristics in a Series Circuit Rating _____

Comments: ____

____

Job Sheet 6—Measure Electrical Characteristics in a Parallel Circuit Rating _____

Comments: ____

____

Unit Evaluation Form

Job Sheet 7—Measure Electrical Characteristics in a Series-Parallel Circuit Rating _____

Comments: ____

____

Job Sheet 8—Adjust Oscilloscope Controls for a Stable Waveform Display Rating _____

Comments: ____

____

Job Sheet 9—Measure Frequency Using an Oscilloscope Rating _____

Comments: ____

____

Job Sheet 10—Measure AC Voltage Using an Oscilloscope Rating _____

Comments: ____

____

Job Sheet 11—Measure DC Voltage Using an Oscilloscope Rating _____

Comments: ____

____

Job Sheet 12—Calibrate an Oscilloscope Probe Rating _____

Comments: ____

____

Written-Test Scores

Pretest _______ Posttest _______ Other _______

Other ____

____

Unit Evaluation Form

Teacher Signature ______________________________ Date ______________

Student Signature ______________________________ Date ______________

***Permission to duplicate this form is granted.**

Shop Orientation and Safety
Unit 2

Supplement 1—Tour an Electronics Workplace

Introduction

There are many points during this course when a tour of an electronics facility would be supportive of the lesson objectives. Therefore, the instructor should feel free to use the suggestions in this supplement whenever a tour of another facility is planned. This supplement includes a survey form that is tailored for use with a tour in support of this unit of instruction, with emphasis on tools and safety. If you choose to conduct a tour in support of a different unit of instruction, you may want to use the survey form in this supplement as a model for constructing a survey form that will be more appropriate for the lesson that tour will support.

The two most important considerations in conducting a successful tour are to ensure that the facilities that you will visit are prepared to receive your group and that the class is prepared to go on the tour. This supplement has suggestions to help you address these considerations.

Directions

Much of the success of the tour depends on your selection of a facility. Choose one that:

- is conveniently close so that a great deal of time is not consumed in transportation.
- performs operations to which the students can relate.
- observes reasonable safety and environmental practices.
- is clean and modern.
- presents a desirable working environment with workers who are generally satisfied with their jobs.
- provides personnel to support the tour.
- will present a professional image.
- can support the tour logistically by providing ESD smocks, safety glasses, and other items required for the tour.
- will be willing to work with you to make the tour a success, including coordination prior to the tour.

A day or two prior to the tour, contact the facility and make sure that they remember the scheduled tour. Make sure that nothing has come up that will interfere with the tour or cause your hosts to be distracted. It may be better to reschedule the tour than to try to conduct it with the shop in a frenzy to meet deadlines or while major renovations are going on. Let the company know the background of your students and what you plan to accomplish with the tour. Conduct your business with professionalism and with a tone that will reassure your host that this tour is part of a strong curriculum and not just a way of occupying the students' time.

After the tour, contact your host again to thank them for their support. Letters from the students can be helpful. In some cases, you may also want someone in your facility's administrative staff to convey thanks to an appropriately high executive at the tour site. In your conversations and correspondence, recognize individuals by name in acknowledging their contributions to the effort. Discuss the results of the tour and student reactions with your contact person. Ask for their suggestions for improving future tours. Where appropriate, offer suggestions that they can consider in hosting future tours.

Prepare your students for the tour as you would any other class session. Tell them what the objective of the visit is, how it relates to what you are studying, and what they should expect to get out of the tour. Also discuss the following, as a minimum:

- the company to be visited—its name and location, what they do, whether they are part of a larger company, how long they have been in business, etc.
- the company's relationship to your facility—are they represented on your advisory board, are past students employees there, have they made other contributions to your program?
- the logistics of the trip—how you will get there, how long it will take, what the students should (and shouldn't) bring, who will be giving the tour, etc.
- highlights of the tour—what the students can expect to see and experience, special equipment or capabilities of the company, innovative procedures (especially as related to your objective), and other important points.
- the survey form and your expectations for the students in completing the form; you may want to provide some specific guidance related to the form, such as, "Note in particular the halon gas fire suppression system they have in their research lab."

During the tour, use available opportunities to reinforce the objectives with the student. For example, if there is a break or lunch, review highlights of the tour already completed and preview those yet to be seen. Get the students to discuss their reactions. In particular, positive reactions from a few key students may help other students to be more receptive to the tour and to recognize points that they may have missed.

After the tour, get the students to discuss what they learned. Use their survey forms or have them use the forms to be more specific about the trip.

Supplement 1

Electronics Facilities Tour Report

Report completed by ______________________________ Date ____________

Company ____

Products or services provided ____

____

Major departments ____

Equipment

Types of equipment ____

Uses ____

Safety

Potential hazards ____

Safety equipment ____

Safety precautions ____

Other safety considerations (posters, accident records, etc.) __________________

____

ESD protection

Personal devices ____

Workstation devices ____

Component handling precautions ___________________________________

Facilities precautions (flooring, ionizers, posters, etc.) _____________________

____

Other comments (make additional comments on the back of this form)

***Permission to duplicate this form is granted.**

Supplement 2—Guidelines for Interpreting MSDSs

Introduction

Modern industries, including the electronics industry, rely heavily on the use of chemicals in their manufacturing and service processes. While most chemicals are entirely safe, others pose some risks. These risks are discussed in the Information Sheet for this unit of instruction. They include direct risks from the chemical (such as toxicity and corrosiveness), risks from the chemicals being exposed to other factors (such as flammability or reactions with other chemicals), and cumulative risks that result from repeated safe exposures that present hazards because of the large number or frequency of the exposures.

There are two primary legal requirements designed to protect workers who are exposed to hazardous chemicals. The first is called the "right-to-know." Under this legislation, every employee is assured the right of knowing the hazards with which they must work. Secondly, companies that manufacture and distribute hazardous substances in the United States are required to provide Material Safety Data Sheets with those substances. The MSDS for each substance explains what the danger is, what level of exposure is dangerous, first-aid treatment for exposure, and other information. As part of the right-to-know legislation, companies are required to make MSDSs for substances used in their facilities available to their employees.

Because MSDSs address so many important issues, they contain a lot of information—some of which deals with the chemistry and other characteristics of the substance which may not be of interest to the average user. But other information on the form is vital to the proper use and storage of the substance and to the worker's safety. Therefore, it is critical that an employee know what is on an MSDS and know how to obtain the information that he or she needs. This supplement will help you become skilled at interpreting MSDSs.

What is an MSDS?

Normally, an MSDS is a printed form. Some companies may maintain MSDSs on computer files, but they are required by law to have the ability to print the form and to provide the form to any employee who requests it and to forward the form to the employee's doctor or designated representative, if so requested. The actual form will vary greatly in appearance from chemical supplier to another. However, the information on the form is specified by law and will be presented in the same basic order in nine sections. Not all sections will apply to any given chemical, but the form will indicate that it does not apply if that is the case. The nine sections may vary somewhat in order and exact contents but generally are:

> **General Information.** Provides the chemical's brand name and actual name; its manufacturer's name, address, and telephone number; and Department of Transportation hazardous materials shipping information.

Ingredients. Lists the chemicals that are in the substance. Often this list will include only those ingredients that are considered to present a health or safety risk. The government or other agencies have defined safe limits for exposure to many chemicals, and these limits may be listed along with the ingredients to which they apply.

Physical Data. This section describes the appearance and odor of the substance in its normal state (dry at room temperature). It also provides information about how much the substance weighs compared to water (whether it will sink in water), the temperature at which it boils (which tells you when it will be a gas), its vapor density compared to air (which tells you whether its vapor will rise or sink in air), whether it dissolves in water, and other information.

Fire and Explosion Data. Tells how flammable the substance is and its *flash point*, the temperature at which the chemical will burst into flames. This section also tells the best media to use to extinguish a fire involving this substance and if special protection is required by firefighters.

Health Hazards. Generally includes the amount of exposure required to pose a health risk, the effects of overexposure, and information on providing first-aid to a victim of overexposure. This section often describes how the substance is likely to enter the body.

Reactivity. Describes dangers of the substance coming into contact with other substances. For example, some chemicals burst into flames when exposed to air or may become a boiling acid if sprayed with water. Some chemicals are safe by themselves, but are poisonous or otherwise hazardous if mixed with each other. These dangerous combinations are called *reactions*.

Environmental Protection Information. Explains how to safely use, store, and dispose of the substance, as well as providing information about what to do in the event of a spill or leak involving the substance.

Personal Protective Equipment Requirements. Lists the equipment required for handling the substance. These may include gloves and aprons, respiratory gear, radiation protection, or other special equipment.

Special Precautions. This section discusses any other dangers that may not be apparent from the other sections. For example, precautions about not puncturing the containers or storing them at high or low temperatures may be listed. This section may provide information about personal hygiene in handling the chemical and other advice on reducing the risks of handling the substance.

How do you obtain an MSDS?

Your facility will maintain one or more files of MSDSs. Simply ask your supervisor or instructor where they are kept in your facility.

When should you refer to an MSDS?

You should study the MSDS for any substance that you are required to work with and with which you are not familiar. You should also review the MSDS of any substance that you use infrequently. Finally, you should review the MSDSs for all the chemicals with which you work periodically. The information on an MSDS may change as continued research reveals new hazards or discovers better ways of protecting users. Every MSDS contains a date for when it was originated and if it has been revised. Check the MSDS files occasionally to see if they have changed since your last review. If you ever have trouble understanding an MSDS or if you find a possible mistake in an MSDS, contact your supervisor.

Special Terms and Abbreviations

MSDSs use a number of terms and abbreviations which may not be familiar to you. Often the form itself will explain such terms and abbreviations. However, a number of terms and abbreviations are frequently used on MSDSs. Some of the more common include:

- **ACGIH**—American Conference of Governmental Industrial Hygienists, one of the agencies that tests chemical hazards and recommends exposure limits.
- **Ceiling**—Uppermost limit, especially in terms of exposure.
- **CHEMTREC**—Organization that tracks hazardous materials as they are being transported and who can provide support in the event of an accident involving hazardous chemicals.
- **DOT**—Department of Transportation, federal agency that regulates interstate transport of goods, including hazardous materials.
- **IDLH**—Immediately Dangerous to Life and Health, the level at which a substance can cause death or permanent harm immediately.
- **LEL**—Lower Explosive Limit, the level below which a substance is too lean to burn.
- **OSHA**—Occupational Safety and Health Act or Occupational Safety and Health Agency, the legislation and the agency responsible for administering the legislation that covers regulation of health and safety in the work place.
- **PEL**—Permissible Exposure Limit, the maximum exposure allowed for a worker in a 40-hour work week, based on the tested or estimated level below which 95 percent of healthy adults would experience no ill effects.
- **ppm**—Parts per million, a unit of measure for the concentration of a substance in another substance such as the air or water.
- **STEL**—Short-time Exposure Limit, a level that is considered safe as long as the exposure does not exceed 15 minutes and does not occur more than 4 times in an 8-hour day with at least 1 hour between exposures.
- **TLV**—Threshold Limit Value, the exposure limit that is considered acceptable for most people under normal working conditions because the average healthy adult is not likely to experience ill effects at this exposure on a daily basis up to 8 hours per day over an extended period of time.
- **UEL**—Upper Explosive Limit, the limit above which a substance is too rich to burn.

Supplement 2

These terms and abbreviations should be helpful in assisting you in understanding MSDSs. If you have questions or are uncertain about the information presented on an MSDS, check with your instructor.

Supplement 3—Sample MSDSs

Introduction This supplement contains sample MSDSs. These can be used to teach the students to interpret MSDSs and can be used in conjunction with Assignment Sheet 1. The materials that are covered by these MSDSs are typical of materials used in the electronics industry.

Directions Use the attached MSDSs as examples or substitute actual MSDSs for materials used in your program.

Note: Sample forms begin on page 63.

Supplement 3

Proton Chemicals, Inc.

2367 Polymer Ave.
Waymire, TX 75235
(512) 555-1200

Material Safety Data Sheet

Pro-Tech Cleaner

A general cleaning solvent designed for use with electronic equipment and components.

Section 1—General Information

Chemical Family: Degreaser **Trade Name:** Pro-Tech Cleaner

DOT Shipping Name: Consumer commodity 48580, Subclass 3

DOT Hazard Classification: ORM-D

Chemtrec Telephone Number: **1-800-424-9300**

Section 2--Ingredients

Principal Components	Threshold Limit Values	
	OSHA	ACGIH
Ethanol (CAS# 64-17-5)	1000 ppm	1000 ppm
Chlorinated Hydrocarbon (CAS# 75-09-2)	500 ppm	100 ppm
Glycol Ethers (CAS# 111-76-2)	50 ppm	25 ppm

Section 3—Physical Data

Appearance: Clear aerosol spray **Odor:** Coconut scent added

Vapor density: 1.9 (Air = 1) **Percent Volatile by Volume:** 68%

Section 4—Fire and Explosion Hazards

Flash Point: Flame projection in excess of 18 inches

Flammability: Spray is flammable **Extinguishing Media:** CO_2, Foam

Fire-Fighting Precautions: Use self-contained breathing apparatus.

Explosion Hazards: Aerosol cans may rupture at temperatures above 130°F.

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Section 5—Health Hazards

Carcinogens: Chlorinated hydrocarbons (animal research only)

Symptoms of Exposure: Dizziness, headaches, eye irritation, nausea; asphyxia or pneumonia if inhaled; may aggravate existing skin or eye sensitivities or complicate upper respiratory conditions

Primary Entry Route: Inhalation

First-Aid Treatment:
Eyes—Flush with water for 15 minutes and contact physician.
Skin—Wash with soap and water. Contact physician if rash or irritation develops.
Inhalation—Move to fresh air. Resuscitate if necessary. Get immediate medical help.
Ingestion—Do **NOT** induce vomiting. Get immediate medical help.

Section 6—Reactivity Data

Stability: Stable

Hazardous Polymerization: Will not occur

Conditions to Avoid: Heat, flames, and sparks

Materials to Avoid: Oxidizing agents

Hazardous Products of Decomposition: Carbon monoxide, carbon dioxide, hydrochloric acid, chlorine, and phosgene

Section 7—Environmental and Disposal Considerations

Storage: Cool, dry place

Clean-Up: Absorb with suitable medium.

Disposal: Incinerate or landfill waste per local, state, and federal regulations. Do **NOT** flush into sewer system. Vent product from cans but do **NOT** puncture aerosol cans.

Section 8—Special Precautions

Eye Protection: Safety glasses recommended

Skin Protection: Neoprene gloves recommended

Respiratory Protection: Maintain vapor concentration below TLV or use organic vapor respirator.

Other: Avoid heat sources; avoid contaminating foods; keep away from children

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ZAP!
Electrical Products

ZAP! Alkaline Batteries

Zap! Electrical Products, Inc.
3800 W. 19th St.
North Sioux City, SD 57049

(605) 555-4ZAP
Zap us on the Internet:
http://www.zep.com

Material Safety Data Sheet

I. Product Information

Chemical Name: Alkaline manganese cell
Trade Name: ZAP! Alkaline Battery
Chemical Family: KOH, MnO_2, Zn, Hg

II. Hazardous Ingredients

Substance	Percent of Product	TLV
Potassium hydroxide (KOH)	25	Ceiling: 2 mg/m^3
Manganese dioxide (MnO_2)	58	Ceiling: 5 mg/m^3
Zinc (Zn)	15	15 mg/m^3
Mercury (Hg)	2	0.1 mg/m^3

III. Physical Data

Characteristic	KOH	MnO_2	Zn	Hg
Boiling Point (°F.)	2408	--	--	674
Specific Gravity ($H_2O = 1$)	2.04	--	--	13.6
Solubility in Water	50%	0	0	0
Percent Volatile by Volume	--	5.03%	7.14%	--
Appearance	Clear liquid	Black powder	Gray powder	Mixed with zinc

IV. Fire and Explosion Data

Extinguishing Media: CO_2, foam

Special Equipment: Firefighters should wear self-contained breathing apparatus

Fire and Explosive Hazards: Batteries may rupture when heated. Once the case is broken, batteries may produce toxic fumes from Hg.

V. Health Hazards

Harmful Effects of Exposure:

Eyes: KOH can cause permanent damage to the eyes.
Skin: KOH is caustic and can burn the skin.
Inhalation: Hg and KOH give off toxic vapors when heated.

First-Aid Treatment:

Eyes: Flush with water for at least 15 minutes and see a physician.
Skin: Wash skin thoroughly. Contact physician if blisters develop.
Inhalation: Remove to safe environment. Resuscitate if necessary.

VI. Reactivity Data

Stability: Stable

Hazardous Polymerization: Will not occur

Hazardous Decomposition Products: Gives off toxic vapors when heated

VII. Spill or Leak Procedures

Spills: If cases rupture, use appropriate absorbent material for KOH and litter clean-up procedures for other substances. Avoid exposure to heat. Avoid skin and eye contact.

Disposal: Do not incinerate. Follow local, state, and federal guidelines for landfill disposal.

VIII. Special Precautions

Storage: Store in a dry place under 85°F.

Handling: Use neoprene, rubber, or latex nitrile gloves when handling corroded or leaking batteries.

Additional Precautions:

Do not recharge.
Replace all batteries in equipment at the same time.
Do not use with non-alkaline batteries.
Do not carry batteries loose in pockets or bags.

Shop Orientation and Safety
Unit 2

Supplement 4—Locate and Report on an MSDS

Introduction An easy way to help your students become familiar with the substances used in your program is to have them review the MSDSs for those substances. However, you may not want each student to have to review every MSDS, especially for substances that they are not likely to use or will not use until much later in the course. This supplement will allow you to address this matter easily by assigning students or groups of students to review MSDSs and reporting their findings. The supplement includes a form that can be used to do the report.

Directions Select the chemicals that are most commonly used in your course or those that present the greatest risks. Assign students or small groups of students to review the MSDSs for these substances. You may want the students or small groups to share their findings with the rest of the class so that everyone will benefit from the research.

Copy and distribute the form on the next page to assist the students in their review.

Supplement 4

Report on a Material Safety Data Sheet

Student Name ______________________________ Date ____________

Name of Substance ____

Manufacturer ____

General uses in this facility _________________________________

Major hazardous ingredients ________________________________

Appearance and odor _____________________________________

Is the substance flammable? __________ Is the substance explosive? __________

What fire extinguishing media is recommended? _______________________

What is the TLV for this substance? _______________________________

What are the indications of overexposure? ___________________________

____

What are the first-aid actions required? ____________________________

____

What, if any, substances will react with this substance? __________________

What should be done in the event of a spill or leak? _____________________

____

What disposal method should be used with this substance? ________________

____

What special precautions should be observed with this substance? __________

____

What special equipment should be used with this substance? ______________

____

*Permission to duplicate this form is granted.

Shop Orientation and Safety
Unit 2

Supplement 5—Survey Facility Fire Extinguishers

Introduction This supplement will help you reinforce the objectives dealing with classes of fires and fire extinguishers. The attached form can be used to have the students determine the locations and types of fire extinguishers in your facilities. The students can do the assignment individually or in small groups. If you have several areas in your facility in which the students will be working, the students or groups can be assigned to the different areas.

Directions Provide the students with the attached form. Discuss the form. Assign the students an area to survey. Have the students complete the survey and report to you or the class about their findings.

Supplement 5

Report on a Fire Extinguisher Survey

Student Name ____ Date ____________________

Area to be surveyed____

Use the space below to draw the area to be surveyed and indicate the location of fire extinguishers with circles and assign each fire extinguisher a number.

For each fire extinguisher provide the following information:

	No. 1	No. 2	No. 3	No. 4
Can be used on fire classes:	______	______	______	______
Can be used on electrical fires?	______	______	______	______

Indicate any other fire extinguishing equipment in the survey area by showing its location with a triangle in the drawing above. Use the space below to describe the additional equipment.

____

____

Indicate the location of fire alarm systems in the survey area with Xs in the drawing above. Use the space below to describe how the alarms are activated.

____

Indicate the location of any emergency power shutoffs in the survey area with squares in the drawing above. Use the space below to describe the equipment served by the shutoffs.

____

Use arrows to show the fire evacuation routes for the survey area.

***Permission to duplicate this form is granted.**

Shop Orientation and Safety
Unit 2

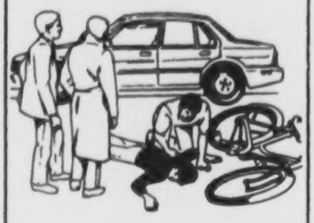
Supplement 6—American Red Cross First-Aid Procedures Booklet

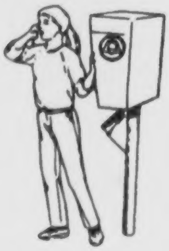
Introduction The attached booklet is produced by the American Red Cross as a quick-reference guide for first-aid. It is available for you to reproduce and distribute to your students. However, you may want to check with your local Red Cross office to see if a more current edition is available. If you invite a resource person from the Red Cross to talk to your class about safety and first-aid, they will often distribute this booklet and other helpful publications.

Directions Use the attached booklet as a handout for all students or as displays to be used in your facility. This supplement can also be used to make transparencies for use in your class presentations.

How to Get Medical Help Fast

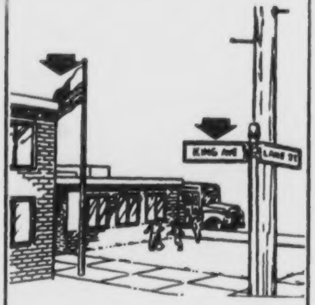
1 - In an emergency, while one person gives care, another can call for help.

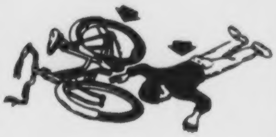




2 - Dial 911 or the local emergency number. Tell the dispatcher . . . (see steps 3, 4, and 5)

3 - Location of the emergency. Include cross streets, room number, and telephone number you are calling from.

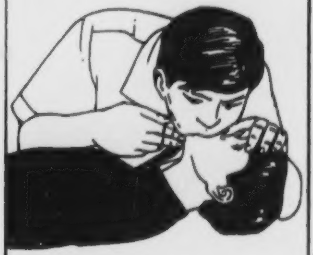


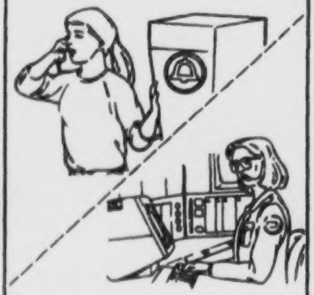


4 - What happened. For example, motor vehicle crash, sudden illness.

What seems to be wrong. For example, victim is bleeding, unconscious.

5 - What first aid is being given. For example, rescue breathing, control of bleeding.





6 - Don't hang up until the dispatcher hangs up. The dispatcher may tell you how to care for the victim.

Return to the scene. Help to care for the victim until help arrives.

Local Emergency Telephone number ______________________________

Everyone should know what to do in an emergency. Call your local American Red Cross ____________________ for information on CPR and first aid courses.

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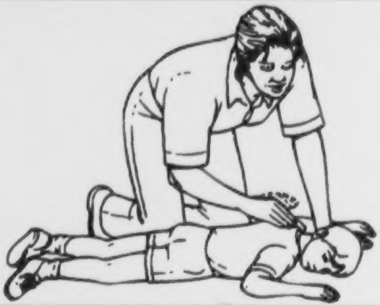
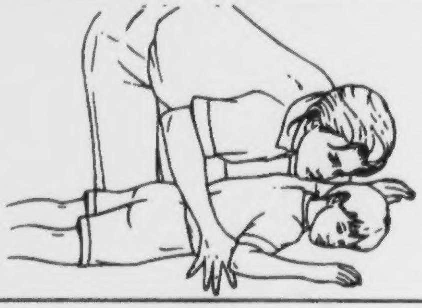
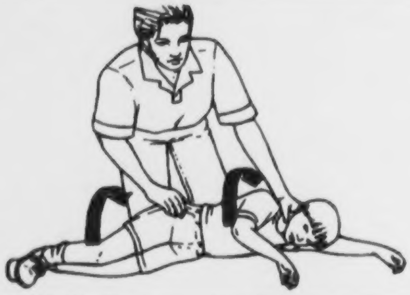
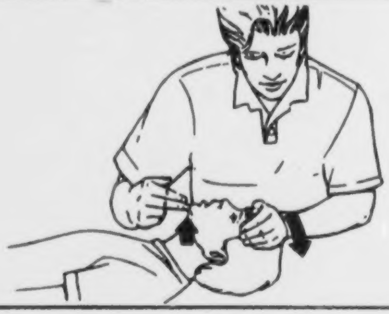
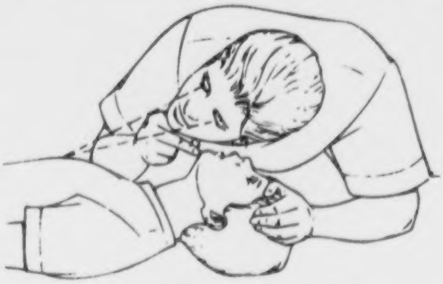
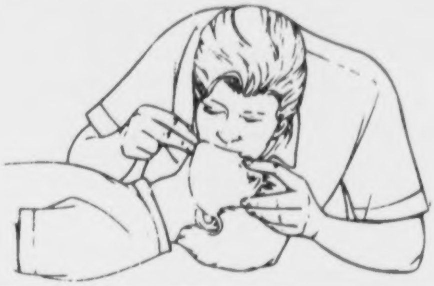
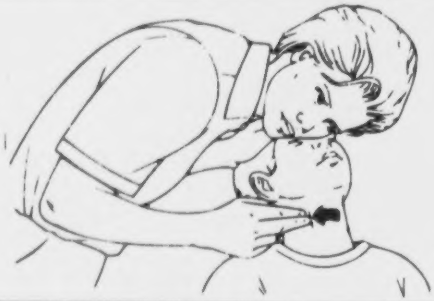
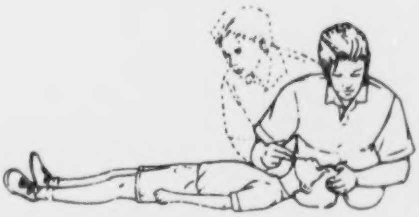
Supplement 6

SKILL SHEET
If the Victim Appears Unconscious . . .
Check the Victim

Step 1: Tap and shout to see if the person responds. *Note: A bystander has been sent to call the local emergency number.*	
If no response . . . **Step 2:** Look, listen, and feel for breathing for about 5 seconds.	
If the person is not breathing or you can't tell . . . **Step 3:** Position victim on back, while supporting head and neck.	
Step 4: Tilt head back and lift chin.	

Supplement 6

Step 5: Look, listen, and feel for breathing for about 5 seconds.	
If not breathing . . . **Step 6:** Give 2 slow breaths.	
Step 7: Check pulse for 5 to 10 seconds.	
Step 8: Check for severe bleeding. ***Give care for the conditions you find.***	

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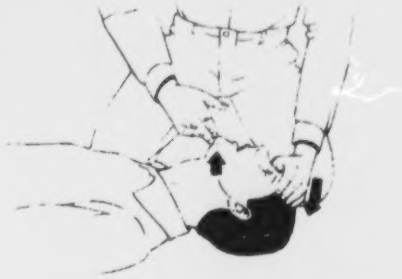
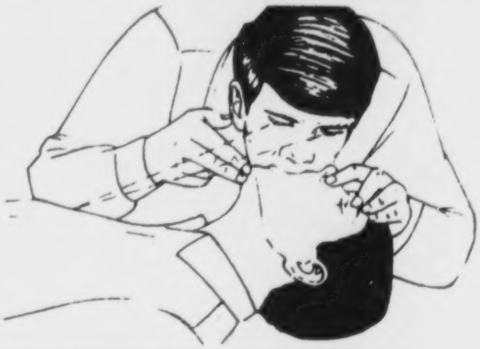
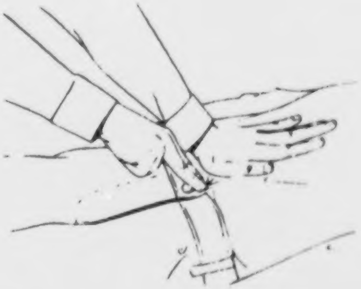
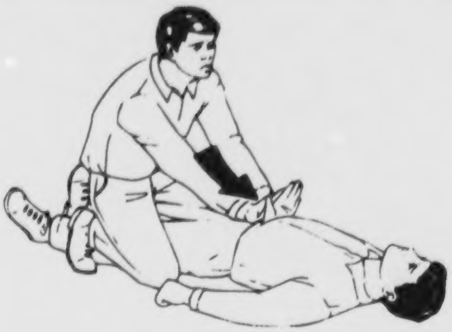
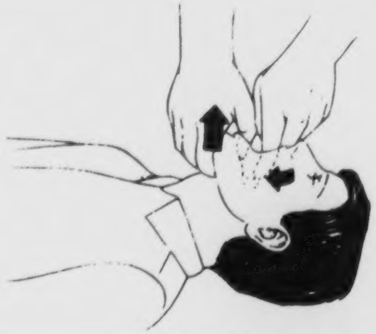
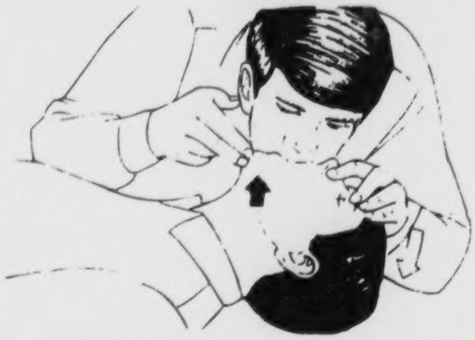
Supplement 6

SKILL SHEET
If Air Does Not Go In . . .
Give Abdominal Thrusts

The emergency number has been called. If, when you check, the person is not breathing and your breaths do not go in . . .

Step 1: Retilt person's head.	
Step 2: Give breaths again.	
If air still won't go in . . . **Step 3:** Place heel of one hand against middle of abdomen just above the navel.	

Supplement 6

Step 4: Give up to 5 abdominal thrusts.	
Step 5: Lift jaw and tongue and sweep out mouth.	
Step 6: Tilt head back, lift chin, and give breaths again ***Repeat breaths, thrusts, and sweeps until breaths go in.***	

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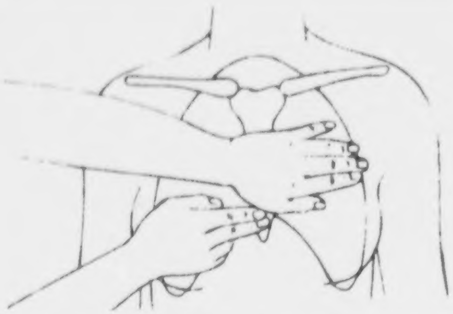
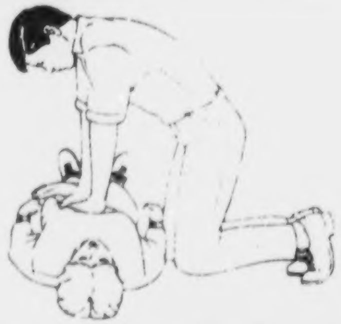
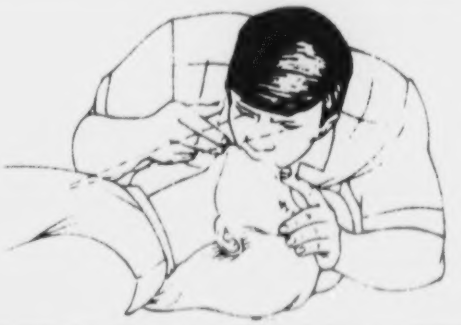
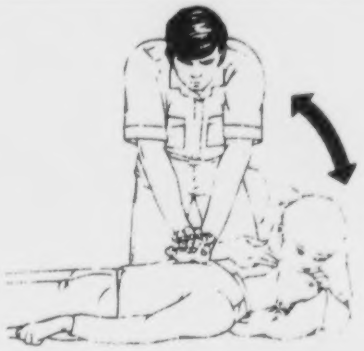
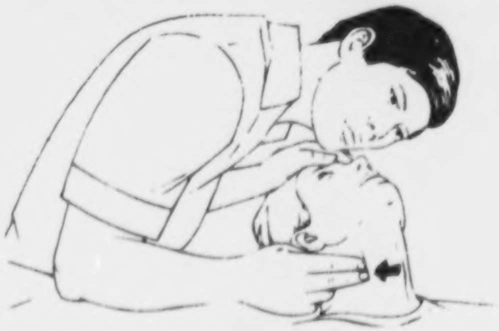
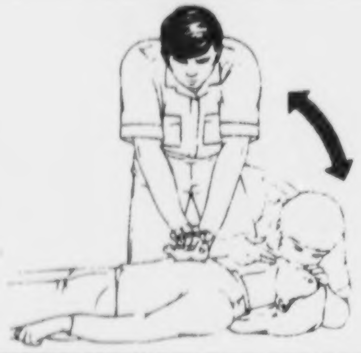
Supplement 6

SKILL SHEET
If Person is Not Breathing and Has No Pulse . . .
Give CPR

The emergency number has been called. If, when you check the person is not breathing and has no pulse . . .

Step 1: Find hand position on breastbone.	
Step 2: Position shoulders over hands. Compress chest 15 times.	
Step 3: Give 2 slow breaths.	

Supplement 6

Step 4: Do 3 more sets of 15 compressions and 2 breaths.	
Step 5: Recheck pulse and breathing for about 5 seconds.	
If there is no pulse . . . **Step 6:** Continue sets of 15 compressions and 2 breaths.	

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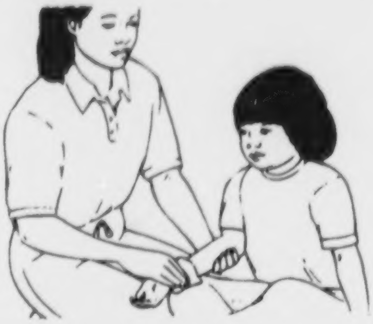
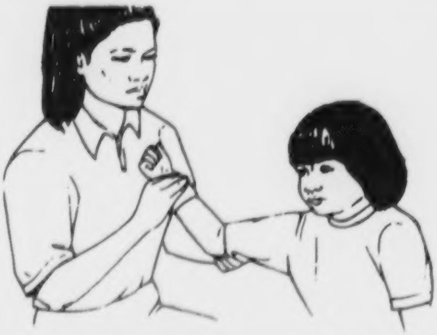
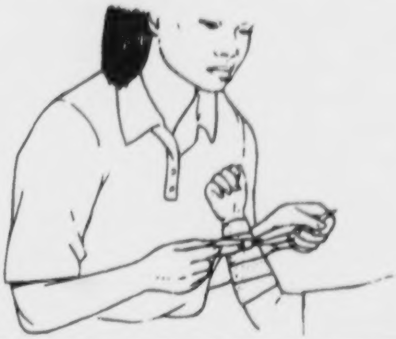
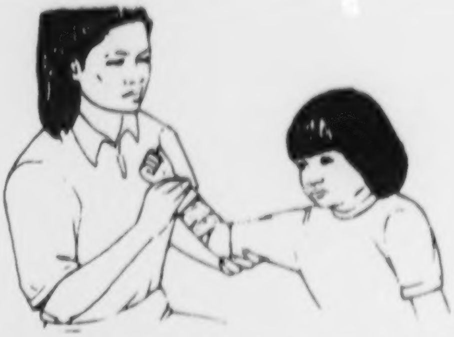
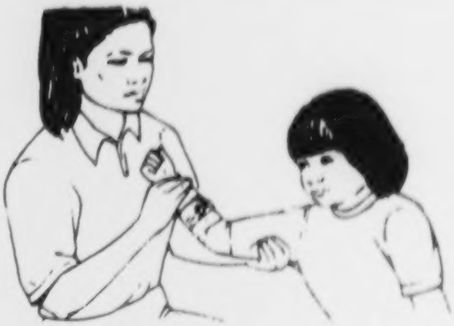
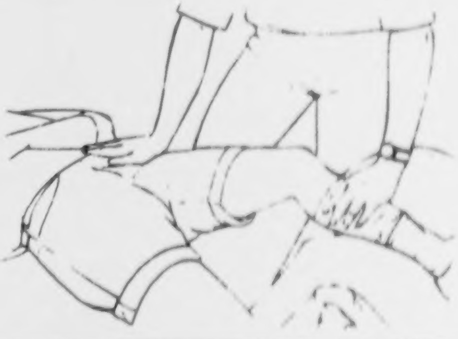
Supplement 6

SKILL SHEET
If a Person is Bleeding . . .
Control Bleeding

Step 1: Cover wound with dressing and press firmly against the wound with hand.	
Step 2: Elevate arm above the level of the heart.	
Step 3: Cover dressings with a roller bandage.	

Supplement 6

If bleeding doesn't stop . . . **Step 4:** Apply additional dressings.	
Step 5: Squeeze artery against bone.	
If bleeding is from the leg, press with the heel of your hand where the leg bends at the hip.	

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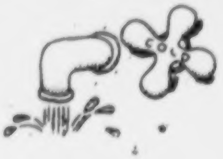
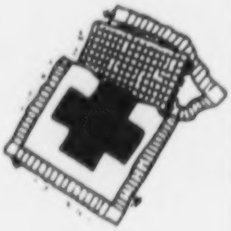
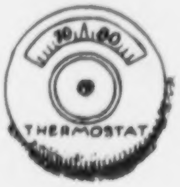
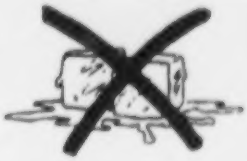
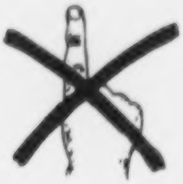
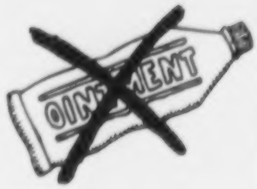
Supplement 6

Dos &	Don'ts of Burn Care
Do cool a burn by flushing with water.  Do cover the burn with a dry, clean covering, such as a sterile dressing.  Do keep the victim comfortable and from being chilled or overheated. 	Don't apply ice directly to any burn unless it is very minor.  Don't touch a burn with anything except a clean covering. Don't remove pieces of cloth that stick to the burned area.  Don't try to clean a severe burn. Don't break blisters. Don't use any kind of ointment on a severe burn. 

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Supplement 7—Using Portable Fire Extinguishers

Introduction

Modern fire extinguishers are marked in several ways to make identification of the types of fires they can be used on as easy as possible. But once the correct fire extinguisher has been selected, you must be able to use it correctly in order to fight the fire effectively and safely. This supplement provides information on how to quickly identify fire extinguishers and gives guidelines for fighting a fire, including a simple four-step method for using most portable fire extinguishers.

Identification

Currently, all fire extinguishers produced and sold in the United States use standard markings to identify the class of fires to which the extinguisher can be applied. These methods are illustrated below and include:

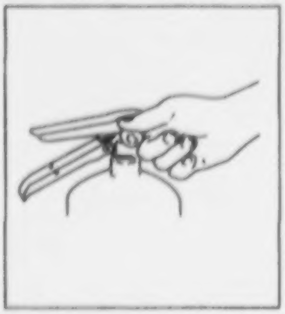
- The class of fire written out
- A large letter identifying the class of fire
- A specific shape surrounding the letter that identifies the class of fire
- A specific color for the shape surrounding the letter that identifies the class of fire
- A drawing that symbolizes the type of fire
- A written description of the type of fire

Supplement 7

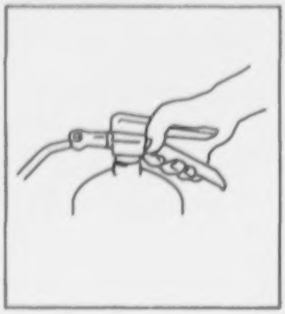
Steps in fighting a fire

1. Notify others in the area of the fire.
2. Size up the fire and determine whether it should be fought with a fire extinguisher. If the fire can **not** be extinguished with a fire extinguisher, evacuate the area and notify the fire department.
3. If the fire is an electrical fire, turn off power to the fire if possible.
4. Obtain an appropriate fire extinguisher.
5. Position yourself so that you can fight the fire while maintaining an exit behind you away from the fire.
6. Hold the fire extinguisher upright by its handle.
7. Check the fire extinguisher label to determine the stream reach of the extinguisher—that is, how far the fire extinguisher will spray extinguishing agent and still be effective. This distance may be as little as 3 feet and as much as 20 feet.
8. Walk—do **not** run—to a safe distance from the fire within the stream reach of the fire extinguisher.
9. Use the PASS sequence to apply the extinguisher: **P**ull the pin; **A**im the nozzle at the base of the fire; **S**queeze the handle; **S**weep the nozzle back and forth along the base of the flames (see illustration below).
10. After the fire appears to be out, probe for hot spots and apply the fire extinguisher to any that you find.

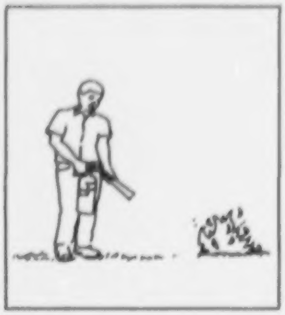
1 **P**ull the pin.



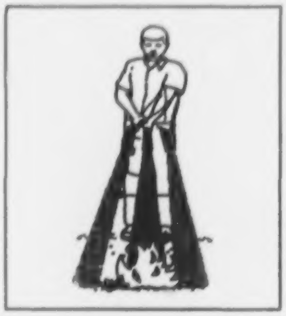
3 **S**queeze the handle.



2 **A**im the nozzle at the base of the fire.



4 **S**weep the nozzle.



Shop Orientation and Safety
Unit 2

Supplement 8—Determine the Resistance of a Meter Movement

Introduction The procedure described in this supplement can be used to demonstrate the use of known resistances to provided calibrated meter movements. You may perform the demonstration or have students construct and operate the circuit themselves to allow them to observe the relationship directly.

This is the first in a series of similar supplements that demonstrate the operation of test equipment. Not only do these exercises provide opportunities to observe the operational principles behind certain types of test equipment, they also allow the students to become familiar with basic tools, components, and procedures that they will be using throughout this course—doing so in a pressure-free situation since these are not evaluated tasks. Because these are not required competencies and because the exercises are similar, you may want to assign each supplement to different students or small groups of students rather than having each student complete each supplement.

Directions Provide the students with the instructions on the next page. Assist them in obtaining the necessary materials and assembling the required circuit. Observe the students as they assemble and operate the circuit. Ask questions to guide them to the correct conclusions about their observations.

Discuss the results of the assignment and their meaning. If the supplement was performed by selected students or small groups, have those students report their findings and conclusions to the class and discuss the results.

Supplement 8

Determine the Resistance of a Meter Movement

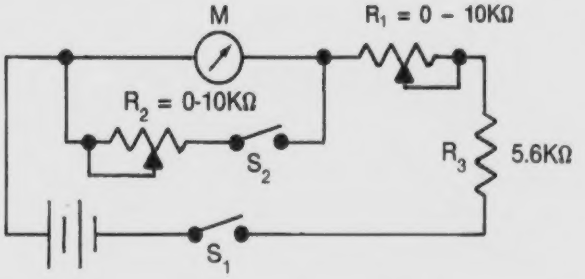
Name ______________________________ Date ____________

A. Equipment and materials

- 1.5-volt battery
- 0-1 milliammeter movement
- 2-10 Kohm potentiometer
- Ohmmeter
- Resistance decade box

B. Procedure

1. Connect the meter circuit shown below.



2. With the switches open, set the meter for 10 volts and the R_1 value at maximum resistance.
3. Close S_1 and decrease R_1 until the meter reads full-scale.
4. Close S_2 and adjust R_2 until the meter reads half-scale.
5. Turn off the power supply and measure the value of R_2.
6. Record the resistance value, which represents the resistance of the meter.
7. Dismantle the circuit and return equipment and materials to their proper storage location.

***Permission to duplicate this form is granted.**

Shop Orientation and Safety
Unit 2

Supplement 9—Construct and Analyze a Voltmeter

Introduction The procedure described in this supplement can be used to demonstrate the construction and operation of a voltmeter. You may perform the demonstration or have students construct and operate the circuit themselves to allow them to observe the relationship directly. See Supplement 8 for additional suggestions on the use of this supplement.

Directions This supplement requires the students to determine the value of a multiplier circuit. If you are going to allow the students to do this procedure, provide instruction on how this is done. If you do this supplement as a demonstration, explain what you did to calculate the multiplier circuit. For purposes of this supplement, the multiplier value can be determined with the formula

$$R_s = \frac{V_{range}}{I_m} - R_m ,$$

where R_s is the multiplier value, I_m is full-scale current, and R_m is the resistance of the meter movement.

Provide the students with the instructions on the next page. Assist them in obtaining the necessary materials and assembling the required circuit. Observe the students as they assemble and operate the circuit. Ask questions to guide them to the correct conclusions about their observations.

Discuss the results of the assignment and their meaning. If the supplement was performed by selected students or small groups, have those students report their findings and conclusions to the class and discuss the results.

Supplement 9

Construct and Analyze a Voltmeter

Name ______________________________ Date ____________

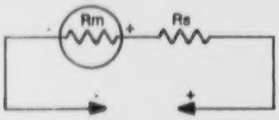
A. Equipment and materials

- Variable power supply
- 0-1 milliammeter movement
- Two 100-Kohm resistors
- Voltmeter
- Resistance decade box (or potentiometer)

B. Procedure

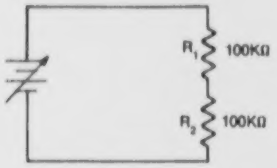
1. Determine the multiplier value required to convert the meter movement into a 30-volt meter and set the R_s value to the calculated multiplier value.

2. Construct the circuit shown below.



3. Adjust the power supply to 15 volts and check it with your meter circuit. What level of meter deflection should you expect and what level did you observe?

4. Construct a second circuit as shown below.



5. Adjust the power supply to 20 volts and use a commercial voltmeter to measure the voltage across R_1. Record the reading.

6. Repeat Step 5 using the voltmeter that you constructed.

7. On the back of this sheet, compare the readings obtained at steps 5 and 6 and explain why you think that they were the same or different.

8. Dismantle the circuit and return equipment and materials to their proper storage location.

*Permission to duplicate this form is granted.

Supplement 10—Construct and Analyze an Ohmmeter

Introduction The procedure described in this supplement can be used to demonstrate the construction and operation of an ohmmeter. You may perform the demonstration or have students construct and operate the circuit themselves to allow them to observe the relationship directly. See Supplement 8 for additional suggestions for using this supplement.

Directions This supplement requires the students to determine the total resistance for the circuit to achieve full-scale deflection. If you are going to allow the students to do this procedure, provide instruction on how this is done. If you do this supplement as a demonstration, explain what you did to calculate the total resistance required. For purposes of this supplement, the resistance value can be determined with the formula

$$R_t = \frac{V}{I_m},$$

where R_t is the required resistance value, I_m is full-scale current, and V is the voltage.

For the circuit used in this supplement, the full-scale current is 1 mA, while the voltage will be the *measured* voltage of the battery.

Provide the students with the instructions on the next page. Assist them in obtaining the necessary materials and assembling the required circuit. Observe the students as they assemble and operate the circuit. Ask questions to guide them to the correct conclusions about their observations.

Discuss the results of the assignment and their meaning. If the supplement was performed by selected students or small groups, have those students report their findings and conclusions to the class and discuss the results.

Supplement 10

Construct and Analyze an Ohmmeter

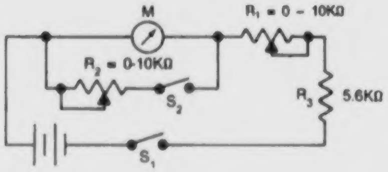
Name ____ Date ____________

A. Equipment and materials

- 1.5-volt battery
- 0-1 milliammeter movement
- 500-ohm potentiometer
- Voltmeter
- Resistance decade box

B. Procedure

1. Connect the meter circuit shown below.



2. Short the terminals together to complete the circuit and adjust the potentiometer R_1 until you get full-scale deflection. This adjustment compensates for the loss of voltage in the battery and is equal to a 0 ohms adjustment on a commercial ohmmeter. Label this position as 0 ohms.

3. Measure and record the battery voltage.

4. Remove the short between the terminals to avoid draining the battery and label the new needle position as ∞.

5. Connect a decade resistance box between the terminals and adjust it for half-deflection of the needle.

6. Measure the resistance value of the decade box and label the 50% deflection point with this value.

7. Repeat Step 6 for 25% and 75% deflections.

8. On the back of this sheet, explain how the ohmmeter could be modified to achieve a 50% deflection value of 50 ohms.

9. Dismantle the circuit and return equipment and materials to their proper storage location.

*Permission to duplicate this form is granted.

Shop Orientation and Safety
Unit 2

Supplement 11—Construct and Analyze an Ammeter

Introduction The procedure described in this supplement can be used to demonstrate the construction and operation of an ammeter. You may perform the demonstration or have students construct and operate the circuit themselves to allow them to observe the relationship directly. See Supplement 8 for additional suggestions on how to use this supplement.

Directions This supplement requires the students to determine the value of a shunt circuit. If you are going to allow the students to do this procedure, provide instruction on how this is done. If you do this supplement as a demonstration, explain what you did to calculate the shunt circuit. For purposes of this supplement, the shunt value can be determined with the formula

$$R_s = R_m \times \frac{I_m}{I_t - I_m},$$

where R_s is the shunt value, I_m is the meter current, and I_t is the total current.

Explain to the students that the shunt circuit is used to increase the range of an ammeter. Thus, the resistance of the shunt must exceed the capability of the basic meter movement. Because the procedure uses a 0-1 mA movement but calls for constructing a 0-10 mA meter, the shunt circuit is necessary and must be designed to provide the proper range.

Provide the students with the instructions on the next page. Assist them in obtaining the necessary materials and assembling the required circuit. Observe the students as they assemble and operate the circuit. Ask questions to guide them to the correct conclusions about their observations.

Discuss the results of the assignment and their meaning. If the supplement was performed by selected students or small groups, have those students report their findings and conclusions to the class and discuss the results.

Supplement 11

Construct and Analyze an Ammeter

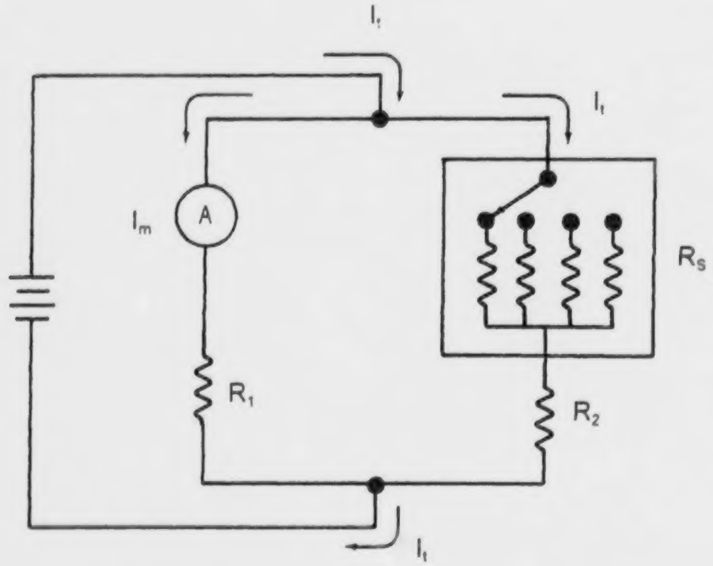
Name ______________________________ Date __________

A. Equipment and materials

- Adjustable power supply
- 0-1 milliammeter movement
- Two 100-Kohm resistors
- Voltmeter
- Resistance decade box or potentiometer

B. Procedure

1. Connect the meter circuit shown below.



2. Modify the above circuit drawing to add the shunt circuit required to convert the 0-1 mA ammeter to a 0-10 mA ammeter.

3. Discuss your shunt circuit design with your instructor.

4. Add the shunt circuit approved by your instructor to the basic meter circuit.

Supplement 11

5. Apply power to the circuit and record the results.
6. Use the space below to describe the performance of your ammeter and to analyze whether the expected results were observed.
7. Remove power from the circuit.
8. Use the back of this sheet to explain how the same circuit could be modified to obtain a 0-50 mA range.
9. Dismantle the circuit and return equipment and materials to their proper storage location.

***Permission to duplicate this form is granted.**

Supplement 12—Conduct an Electrical Survey of Your Facility

Introduction This supplement will allow your students to gain a better understanding of the electrical capabilities and design of your facility or another facility that you choose to have them survey. This activity will help to satisfy entry-level training requirements for the Electronic Industries Foundation.

Directions Provide the students with a copy of the form on the next page. Discuss the form with the students and help them to see how the information to be collected relates to what they have studied (or will study) in the unit. Discuss the importance of suitable, stable electrical power in the workplace and how faulty power or electrical interference can cause problems in the manufacture or testing of electronic equipment.

Help the students to understand what type of information you want with each item on the form and ways in which they may obtain that information. Demonstrate procedures that may not be clear to the students.

Ask the students to survey their assigned area or to observe you doing the survey. Supplement the survey or ask questions that will tailor the survey to your facility. For example, if your facility has isolation transformers or special grounding networks, ensure that these features are addressed in the survey.

The students may do the project as individuals or in small groups. If possible have them share their study with other members of the class. This can be accomplished through oral reports, creation of posters, demonstrations, videotapes, or other methods.

Report on Facility Electrical Survey

Student Name ______________________ Date ____________

Name of Facility ______________________

Use the back of this form to draw a floor plan of the area that was surveyed. Indicate significant electrical features on the floor plan.

Describe Utility Power Service to the Facility ______________________

____

Describe Power Panel(s) in Surveyed Area ______________________

____

Describe Equipment Master Power Switches in the Surveyed Area ______________________

____

Measured Voltage at an Outlet in the Surveyed Area ______________________

Describe Special Power Isolation Features in the Surveyed Area ______________________

____

Describe Special Grounding Features in the Surveyed Area ______________________

____

Describe Potential Electrical Problems (Inadequate Power, Interference, Etc.) in the Surveyed Area ______________________

____

Describe Potential Electrical Safety Problems in the Surveyed Area ______________________

____

Other Pertinent Information ______________________

____

*Permission to duplicate this form is granted.

Supplement 13—Conduct an Environmental Survey of Your Facility

Introduction This supplement will allow your students to gain a better understanding of the potential environmental impact and design of your facility or another facility that you choose to have them survey. This activity will help to satisfy entry-level training requirements for the Electronic Industries Foundation.

Directions Provide the students with a copy of the form on the next page. Discuss the form with the students and help them to see how the information to be collected relates to what they have studied (or will study) in the unit. Discuss the importance of providing a safe and comfortable working environment for employees and one in which the public is protected from potential hazards.

Help the students to understand what type of information you want with each item on the form and ways in which they may obtain that information. Identify personnel and resource locations for information that the students may need. Demonstrate procedures that may not be clear to the students, such as measuring light and sound levels.

Ask the students to survey their assigned area or to observe you doing the survey. Supplement the survey or ask questions that will tailor the survey to your facility. For example, if your facility has special ventilation equipment, noise reduction features, or other environmental design elements, ensure that these are addressed in the survey.

The students may do the project as individuals or in small groups. If possible have them share their study with other members of the class. This can be accomplished through oral reports, creation of posters, demonstrations, videotapes, or other methods.

Discuss the types of engineers and technicians that would do surveys such as this and the training requirements and career opportunities for such personnel.

Supplement 13

Report on Facility Environmental Survey

Student Name ______________________________ Date ________________

Name of Facility ____

Use the back of this form to draw a floor plan of the area that was surveyed. Indicate significant environmental features on the floor plan.

Record the Following Information for the Survey Area:

Light Level at Work Area __________ Foot-candles

Noise Level at Work Area __________ dB

Temperature in Work Area __________ °F

Humidity in Work Area __________ % Relative Humidity

Describe Any Factors that Interfere with Worker Comfort (Odors, Fumes, Etc.) ____________

____

Describe Any Special Environmental Features of the Surveyed Area ____________________

____

Describe the Storage of Hazardous and Flammable Materials in the Surveyed Area ________

____

Check Those Items Below that Are Available to Workers in This Facility

_____ Restrooms

_____ Nurse or Doctor on Site

_____ MSDSs

_____ Eye Protection

_____ Break Area

_____ First-Aid Kit

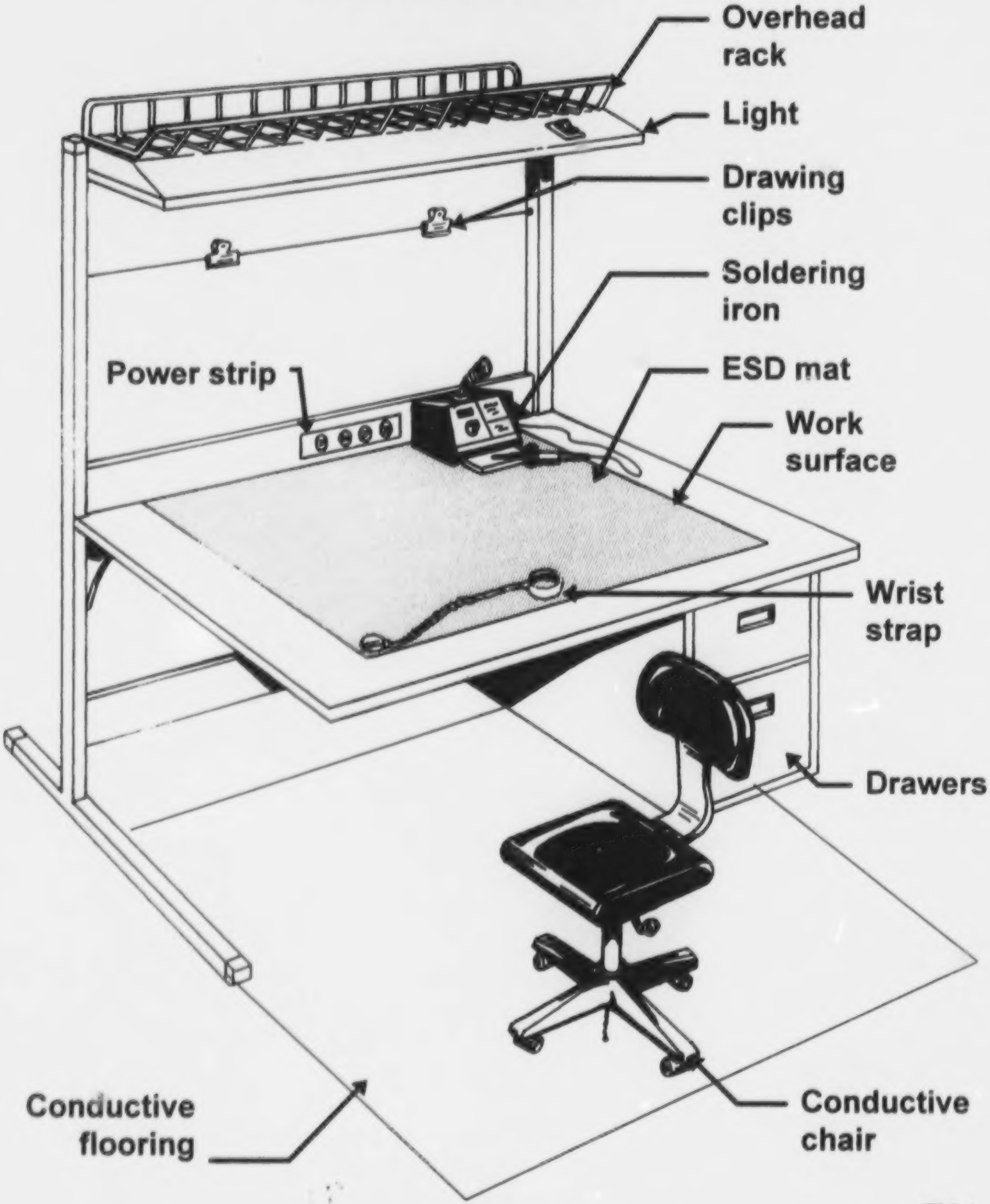
_____ Eye Wash Station

_____ Ear Protection

Use the back of this sheet to describe any formal surveys conducted in this facility by any of the following: OSHA, EPA, local government agencies, insurance companies, etc. Give the date of such surveys and summarize the results. If problem areas were identified, describe if and how they were corrected.

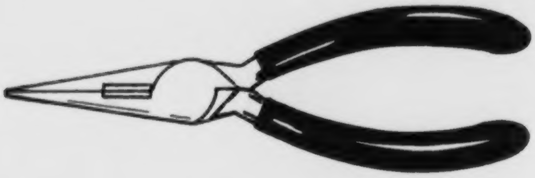
*Permission to duplicate this form is granted.

Parts of a Typical Electronics Workstation

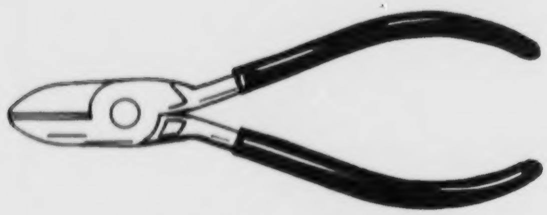

Overhead rack
Light
Drawing clips
Soldering iron
Power strip
ESD mat
Work surface
Wrist strap
Drawers
Conductive flooring
Conductive chair

TM 1

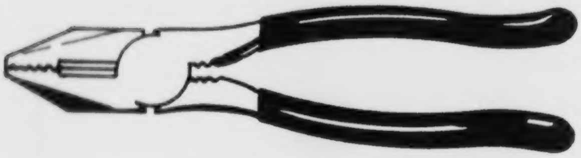
General Hand Tools



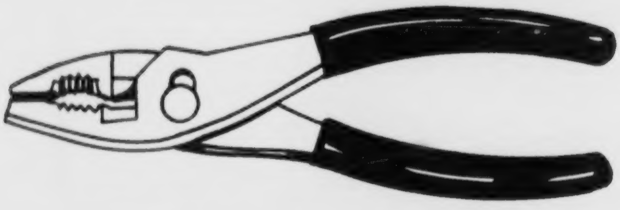
Long Nose Pliers



Diagonal Cutting Pliers

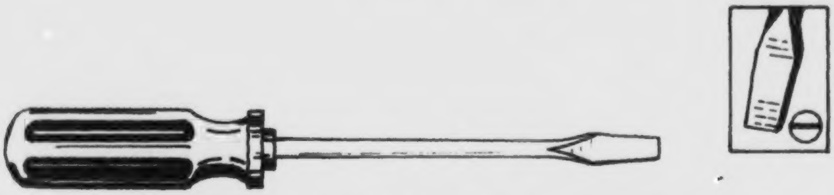


Lineman's Side Cutting Pliers

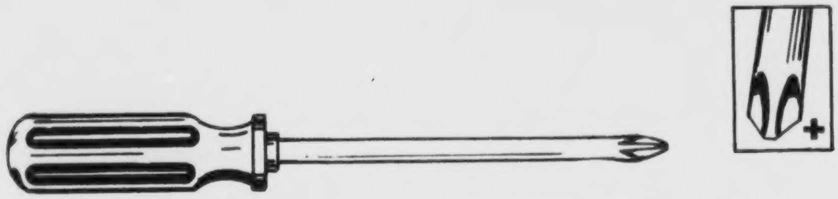


Combination Slip-Joint Pliers

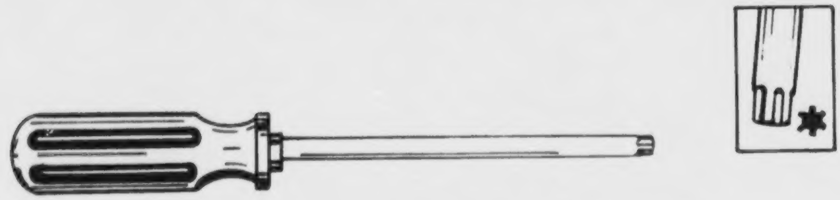
General Hand Tools
(Continued)



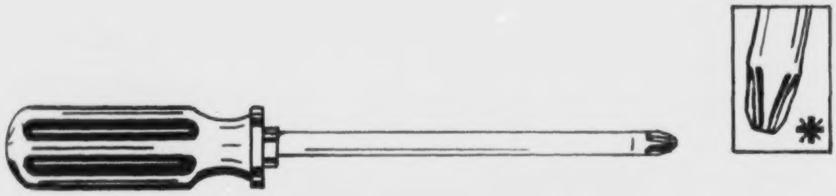
Flat-Blade (Slot Head) Screwdriver



Phillips® Head (Cross-Point) Screwdriver



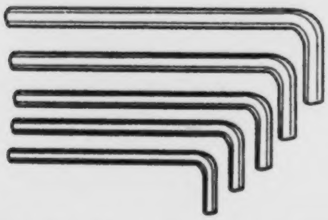
Torx® (Star Fastener) Driver



Pozidriv® Driver

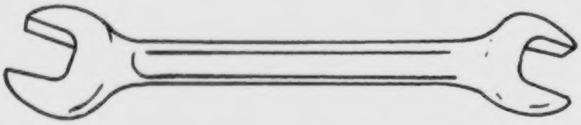
General Hand Tools

(Continued)

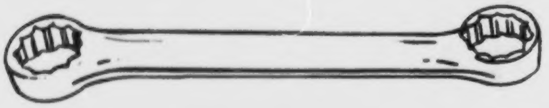


Hex and Spline (Allen) Wrench

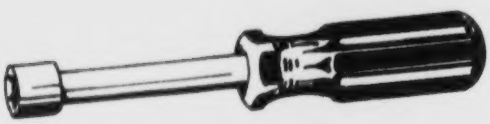
Adjustable Wrench



Open-End Wrench

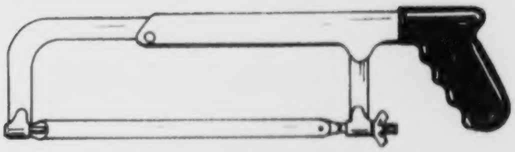


Box-End Wrench

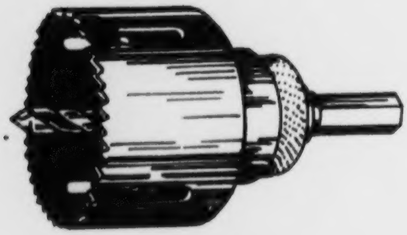


Nut Driver

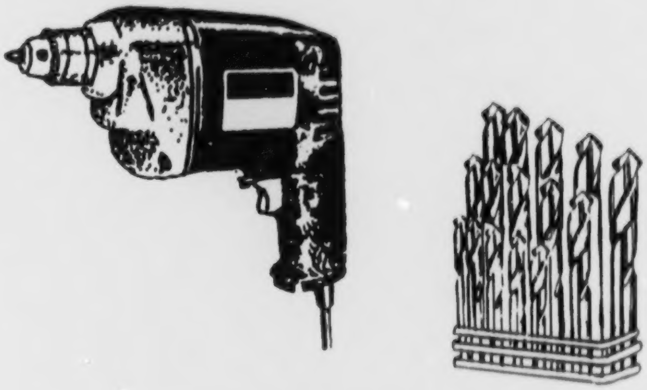
General Hand Tools
(Continued)



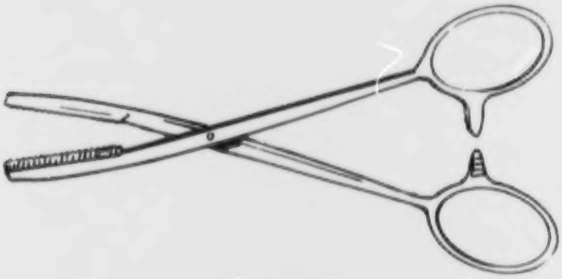
Hacksaw



Hole Saw



Drill and Drill Bits

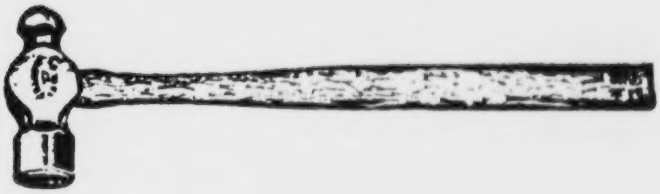


Hemostat Clamp

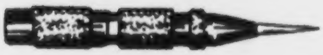
TM 5

General Hand Tools

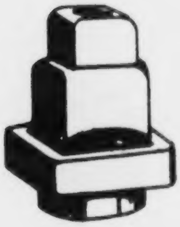
(Continued)



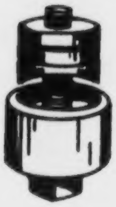
Ball Peen Hammer



Center Punch



Square-Hole Punch



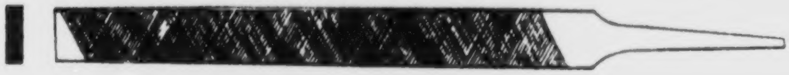
Round-Hole Punch

319

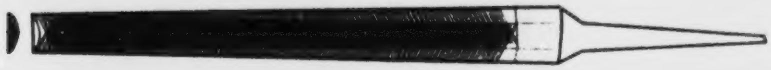
TM 6

General Hand Tools

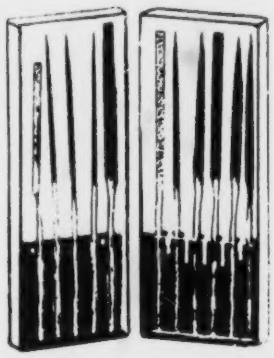
(Continued)



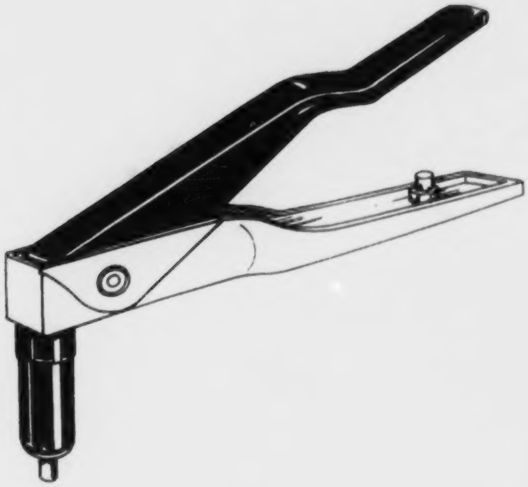
Flat File



Half-Round File

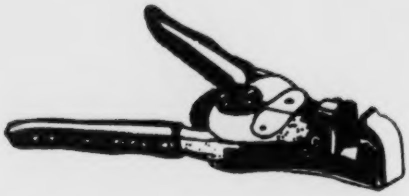


Precision Files

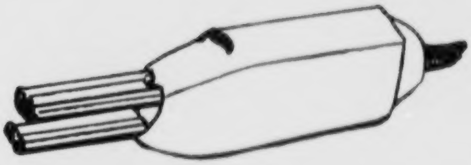


Rivet Gun

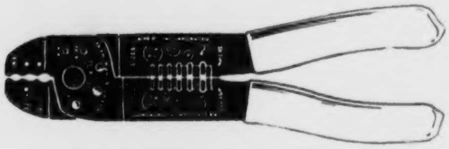
Wire Preparation and Assembly Tools



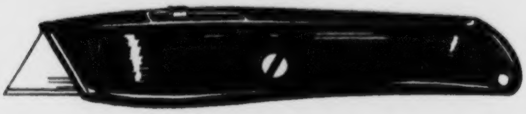
Mechanical Wire Strippers



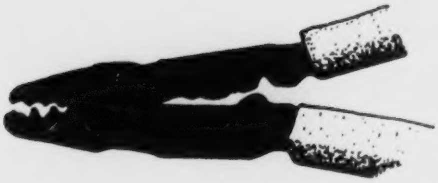
Thermal Wire Stripper



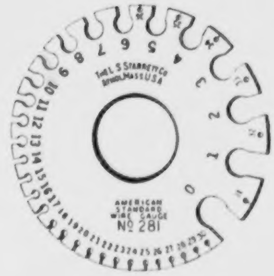
Electrician's Six-in-One Tool



Utility Knife



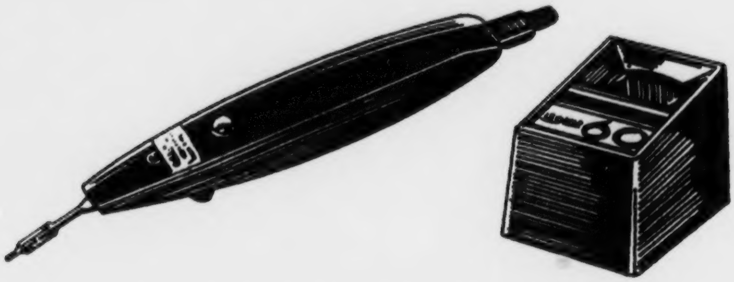
Crimping Tool


AMERICAN STANDARD WIRE GAUGE
Nº 281

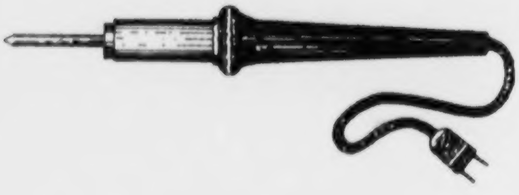
Wire Gauge

TM 8

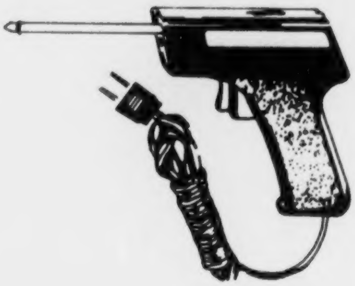
Soldering Tools



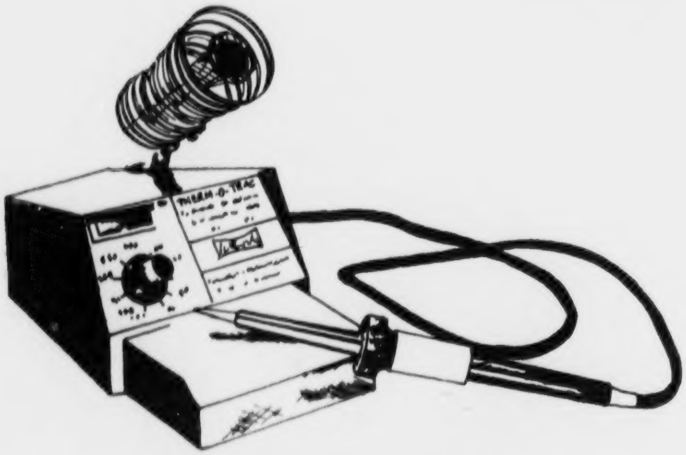
Hand Soldering Machine



Soldering Pencil



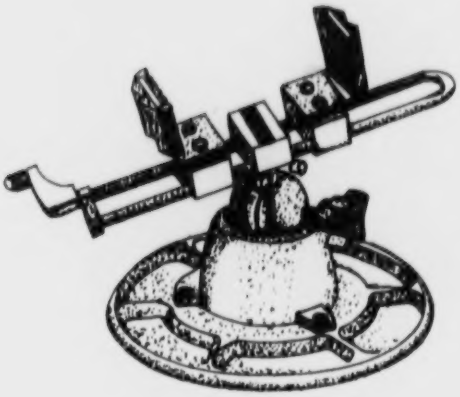
Soldering Gun



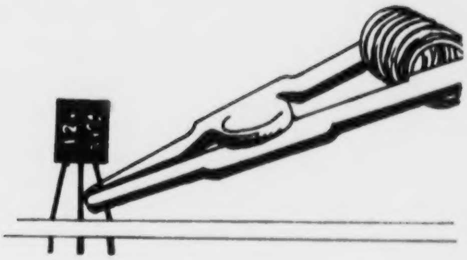
Soldering Iron and Stand

TM 9

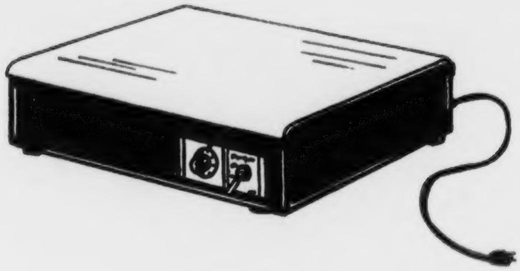
Soldering Tools
(Continued)



Circuit Board Vise

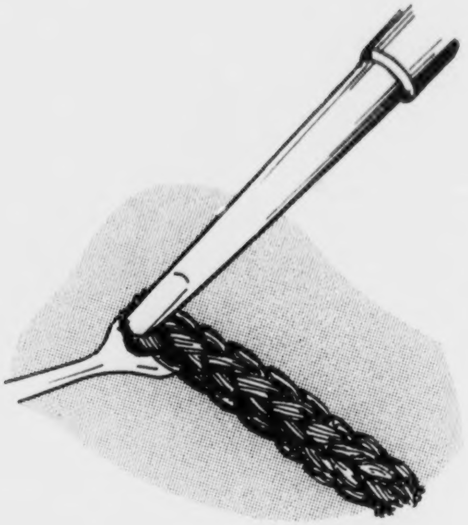


Heat Sink

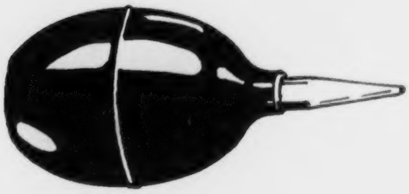


Hot Plate

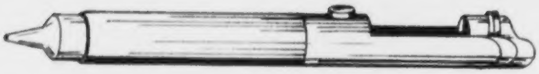
Soldering Tools
(Continued)



Solder Wick

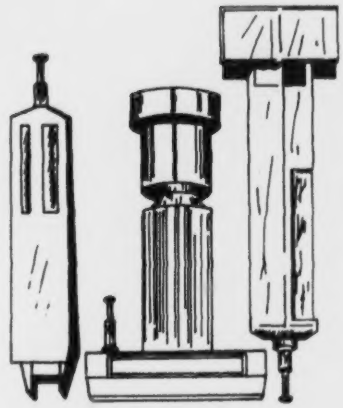


Desoldering Bulb

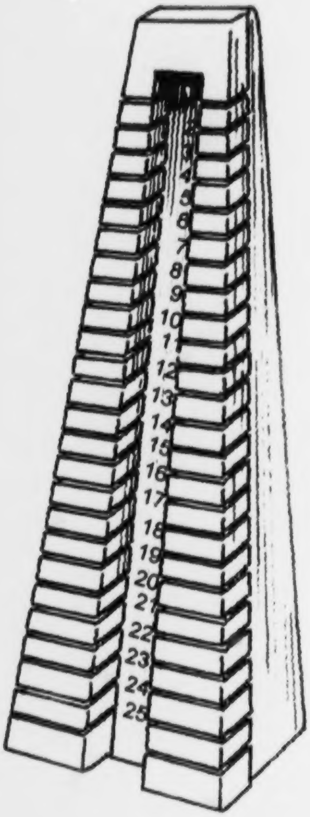


Solder Sucker

Electronic Component Handling and Preparation Tools



Insertion Tools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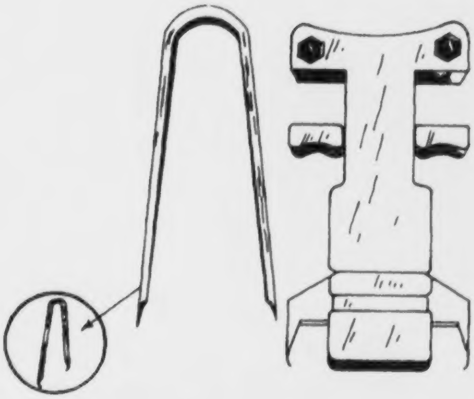
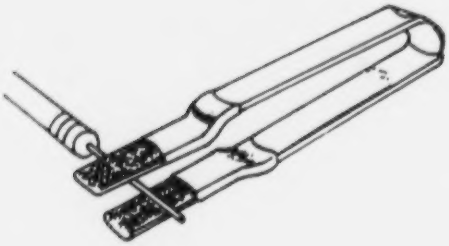
Lead-Forming Die



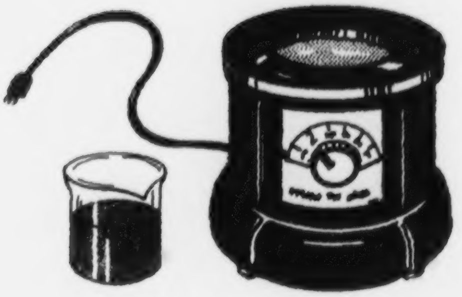
Extraction Tools

Electronic Component Handling and Preparation Tools

(Continued)

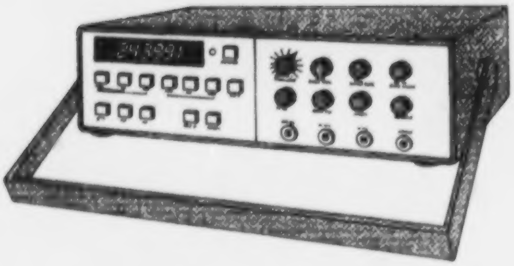


Component Lead Cleaner

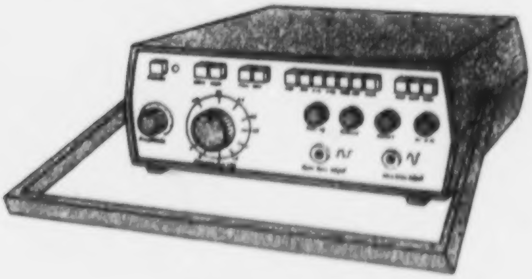


Tinning Equipment

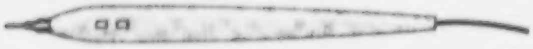
Electronic Test Equipment and Inspection Tools



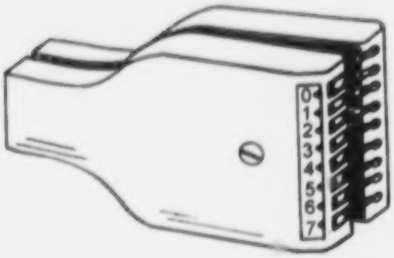
Function Generator



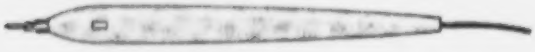
Signal Generator



Logic Probe

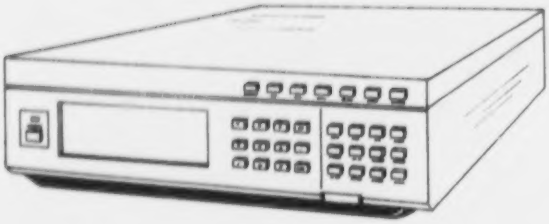


Logic Clip

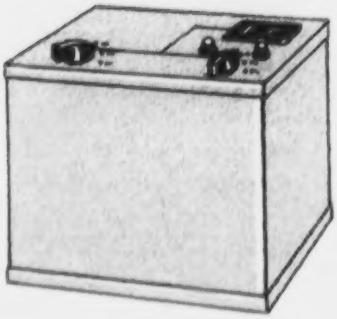


Logic Pulser

Electronic Test Equipment and Inspection Tools
(Continued)

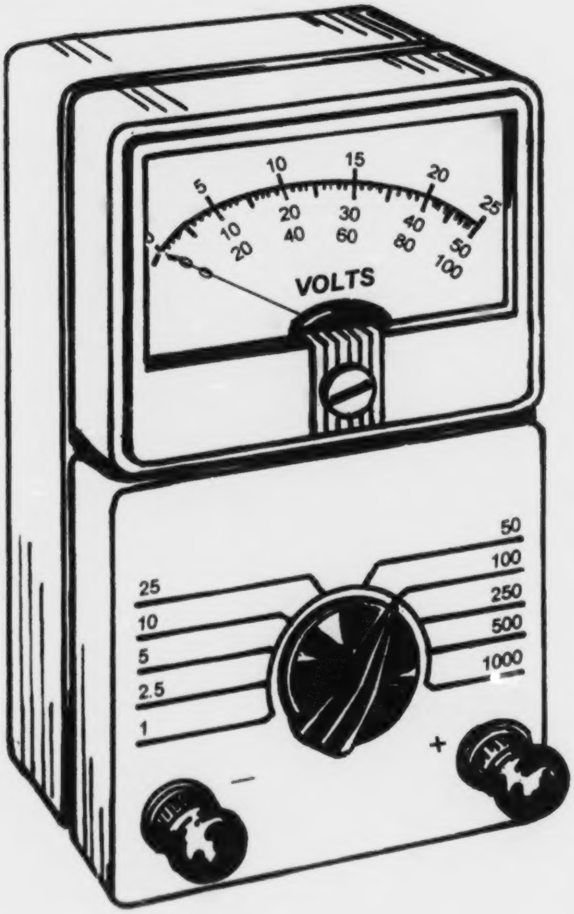


Power Supply

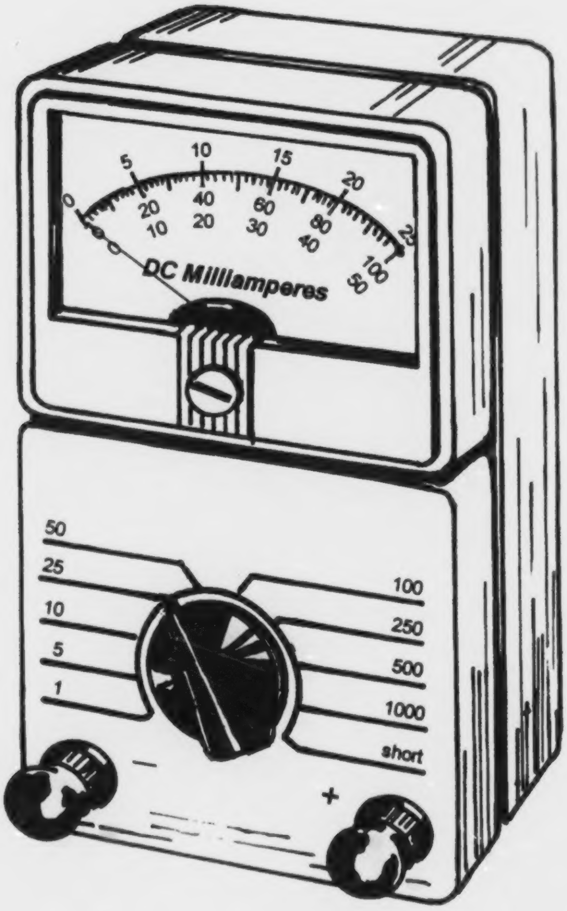


Isolation Transformer

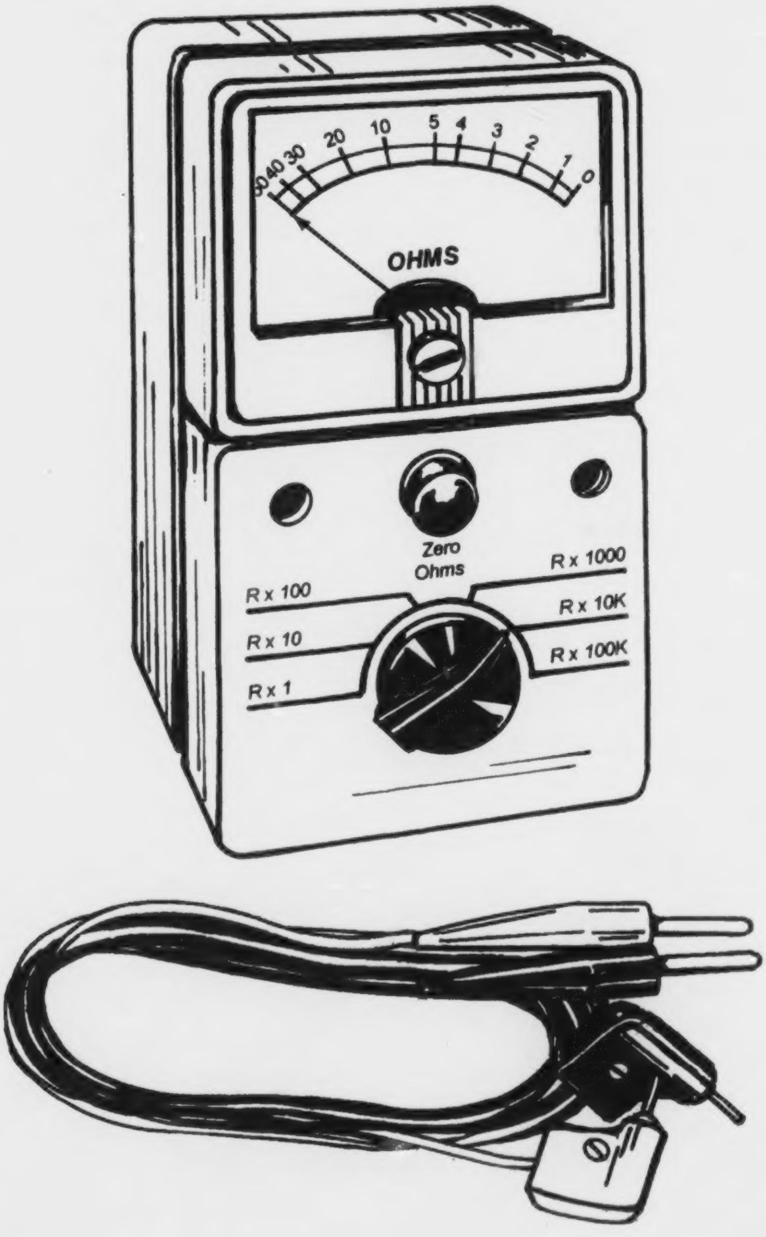
Analog Voltmeter


5
10
15
20
25
10
20
30
40
50
20
40
60
80
100
VOLTS
25
10
5
2.5
1
50
100
250
500
1000
+
−

Ammeter


DC Milliamperes
short
−
+

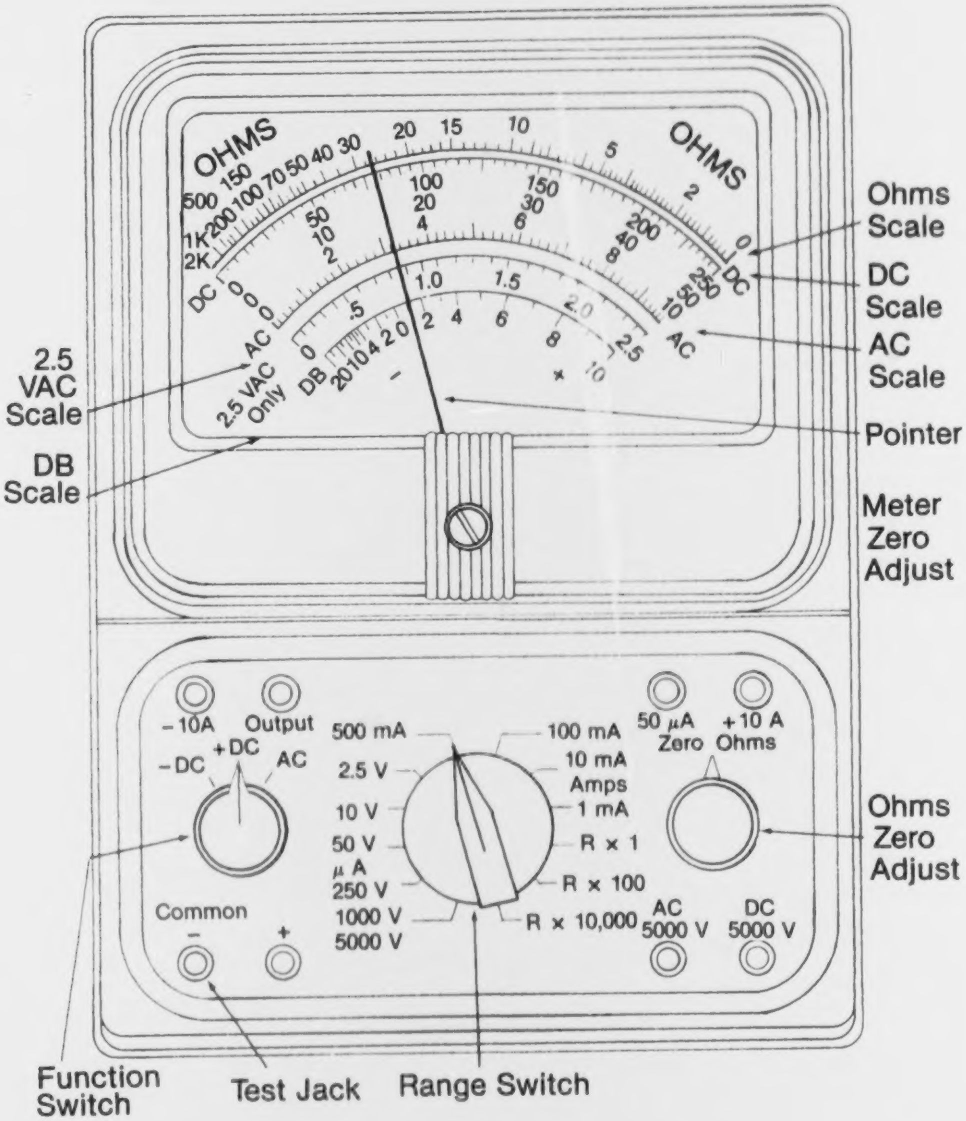
Ohmmeter


50
40
30
20
10
5
4
3
2
1
0
OHMS
Zero Ohms
R x 100
R x 10
R x 1
R x 1000
R x 10K
R x 100K

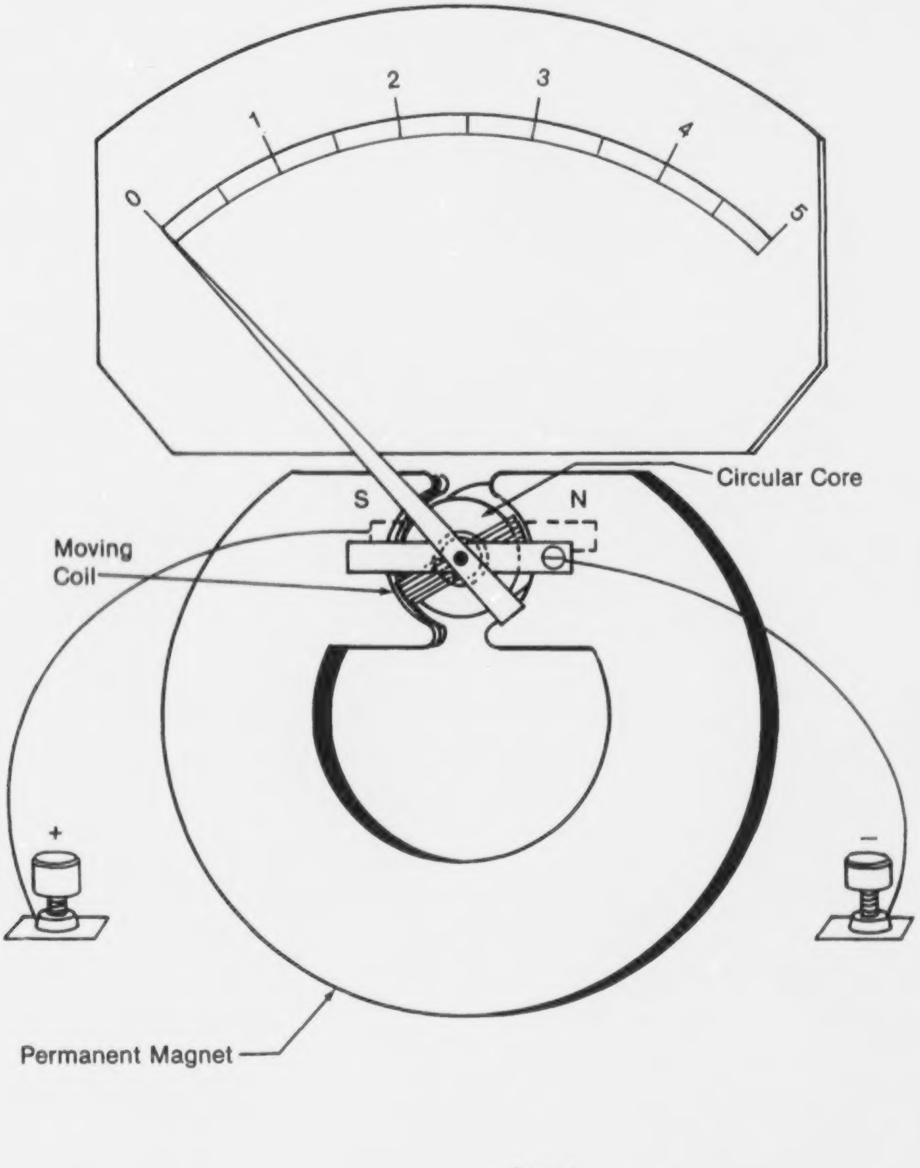
331

TM 18

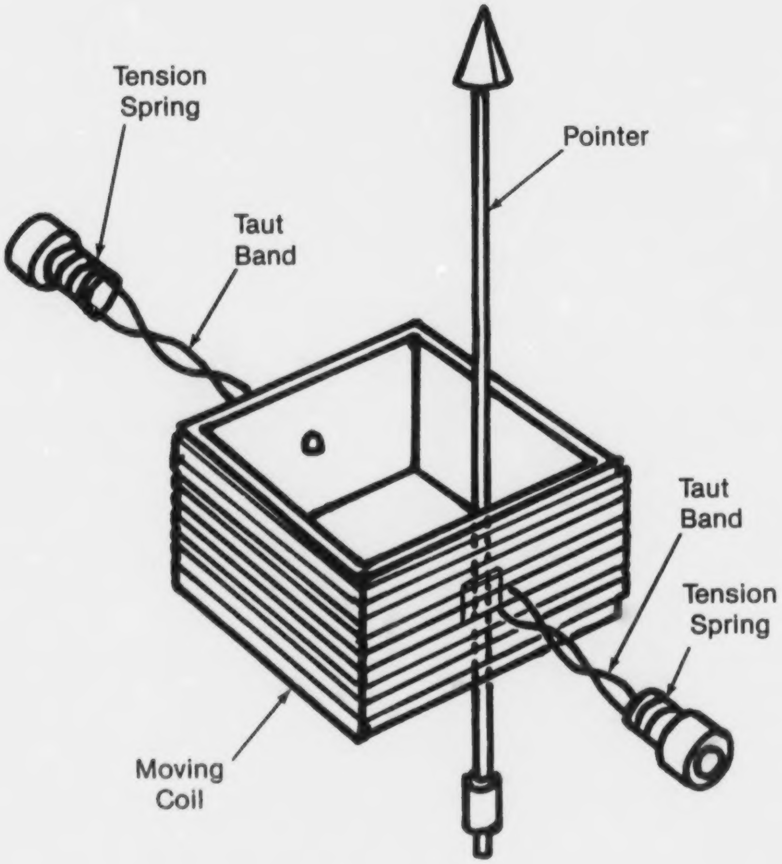
Multimeter


Ohms Scale
DC Scale
AC Scale
2.5 VAC Scale
DB Scale
Pointer
Meter Zero Adjust
Ohms Zero Adjust
Function Switch
Test Jack
Range Switch
OHMS
OHMS
DC
AC
2.5 VAC Only
DB
-10A
Output
-DC
+DC
AC
Common
−
+
500 mA
2.5 V
10 V
50 V
μ A
250 V
1000 V
5000 V
100 mA
10 mA
Amps
1 mA
R × 1
R × 100
R × 10,000
50 μA
Zero
+10 A
Ohms
AC
5000 V
DC
5000 V

Moving Coil Meter
(D'Arsonval Movement)


0
1
2
3
4
5
Circular Core
S
N
Moving Coil
+
–
Permanent Magnet

Taut-Band DC Meter


Tension Spring
Pointer
Taut Band
Taut Band
Tension Spring
Moving Coil

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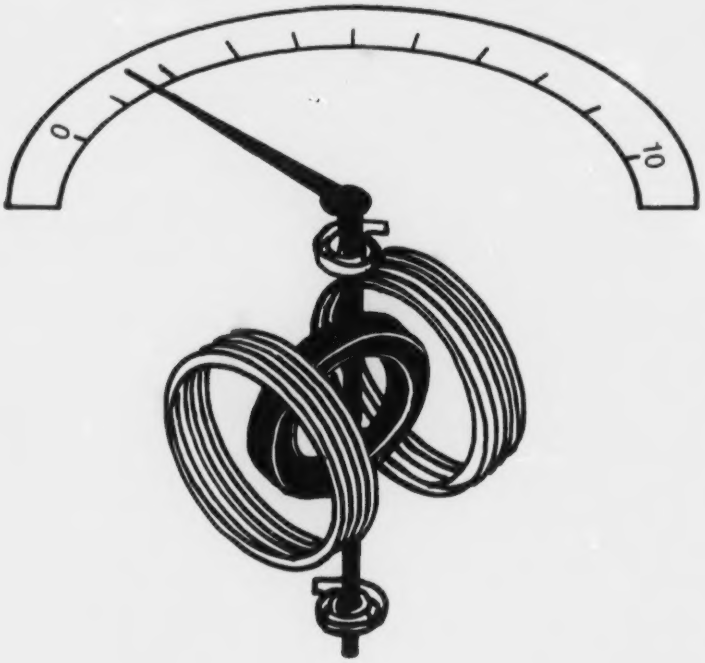
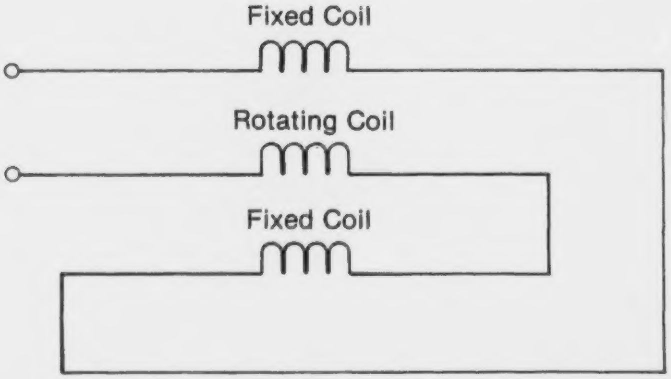
Electrodynamometer




Fixed Coil
Rotating Coil
Fixed Coil

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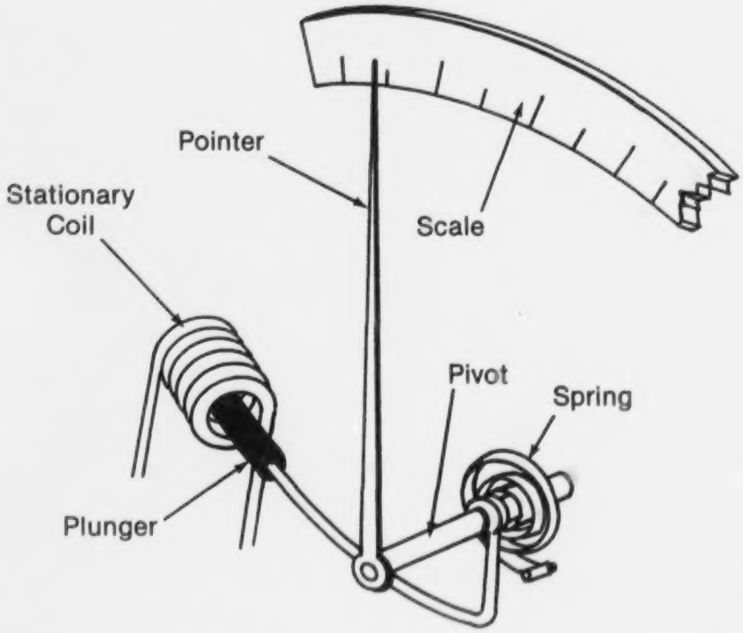
TM 22

Iron Vane Meter


Pointer
Stationary Coil
Scale
Pivot
Spring
Plunger

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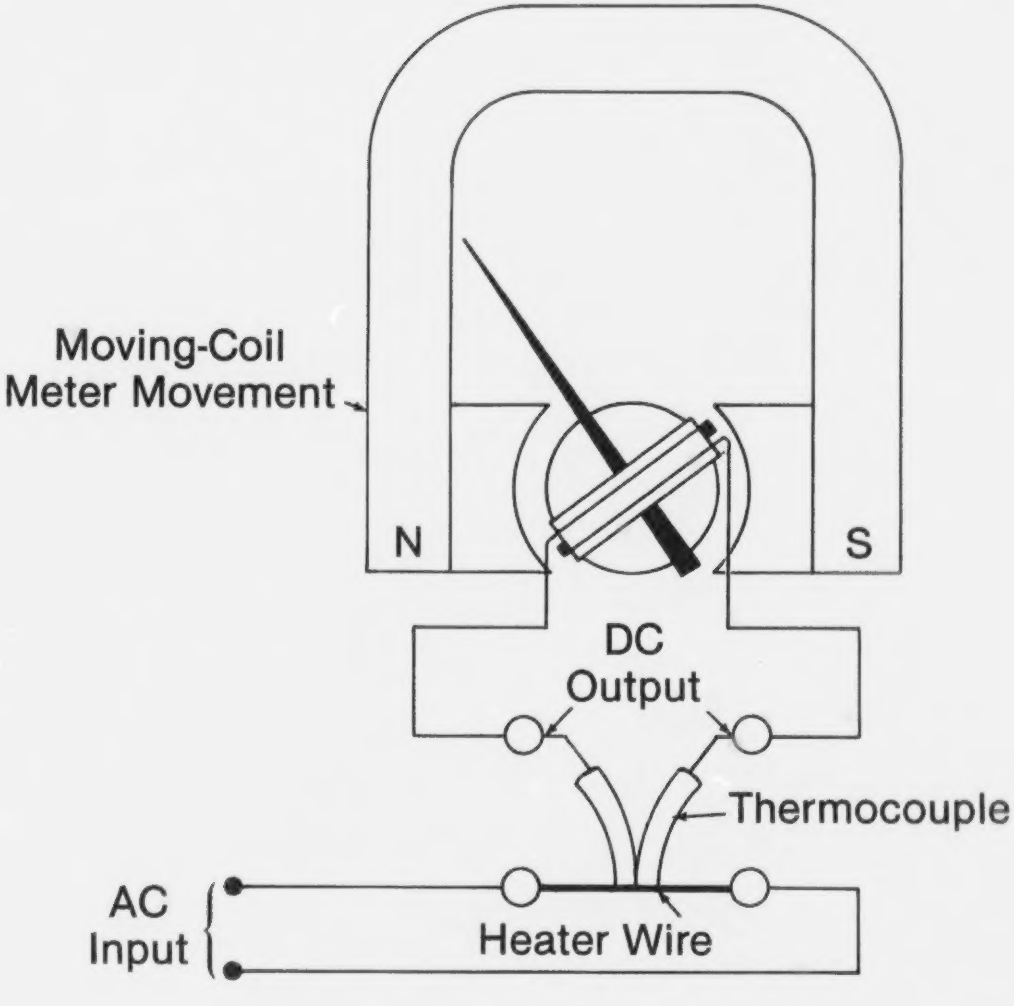
Thermocouple Meter


Moving-Coil Meter Movement
N
S
DC Output
Thermocouple
AC Input
Heater Wire

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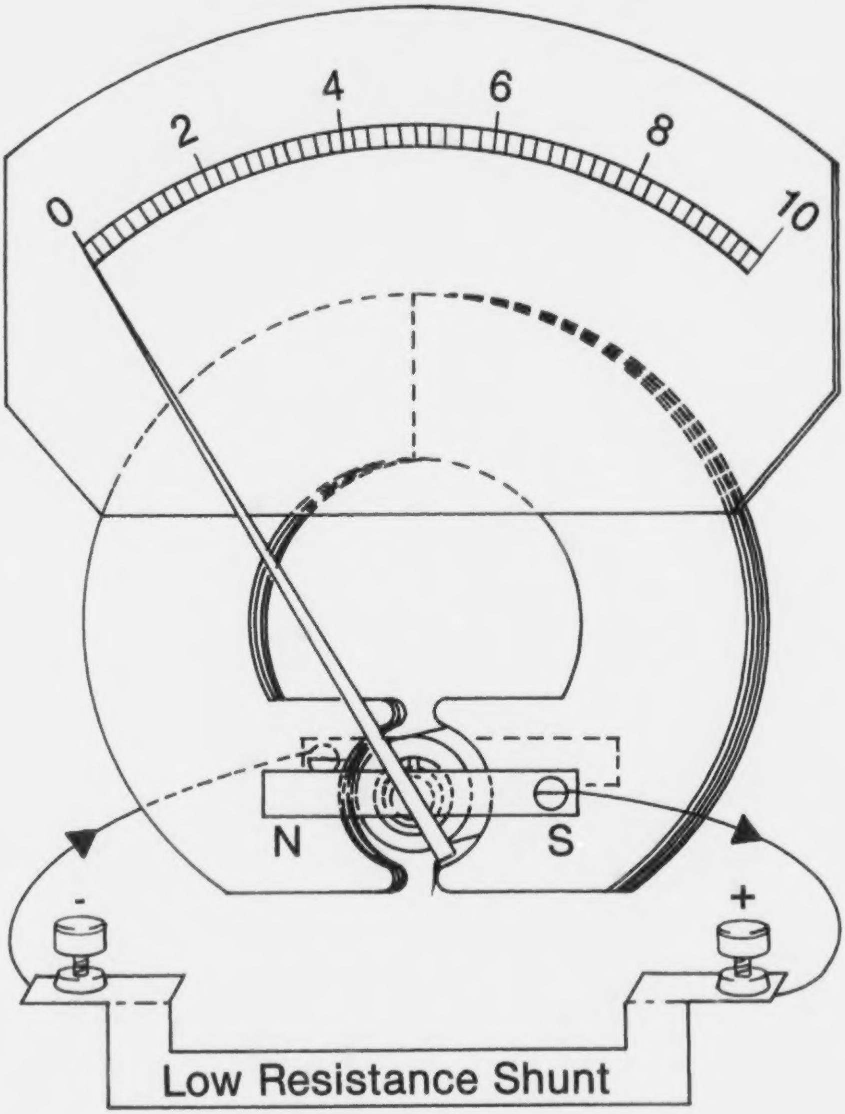
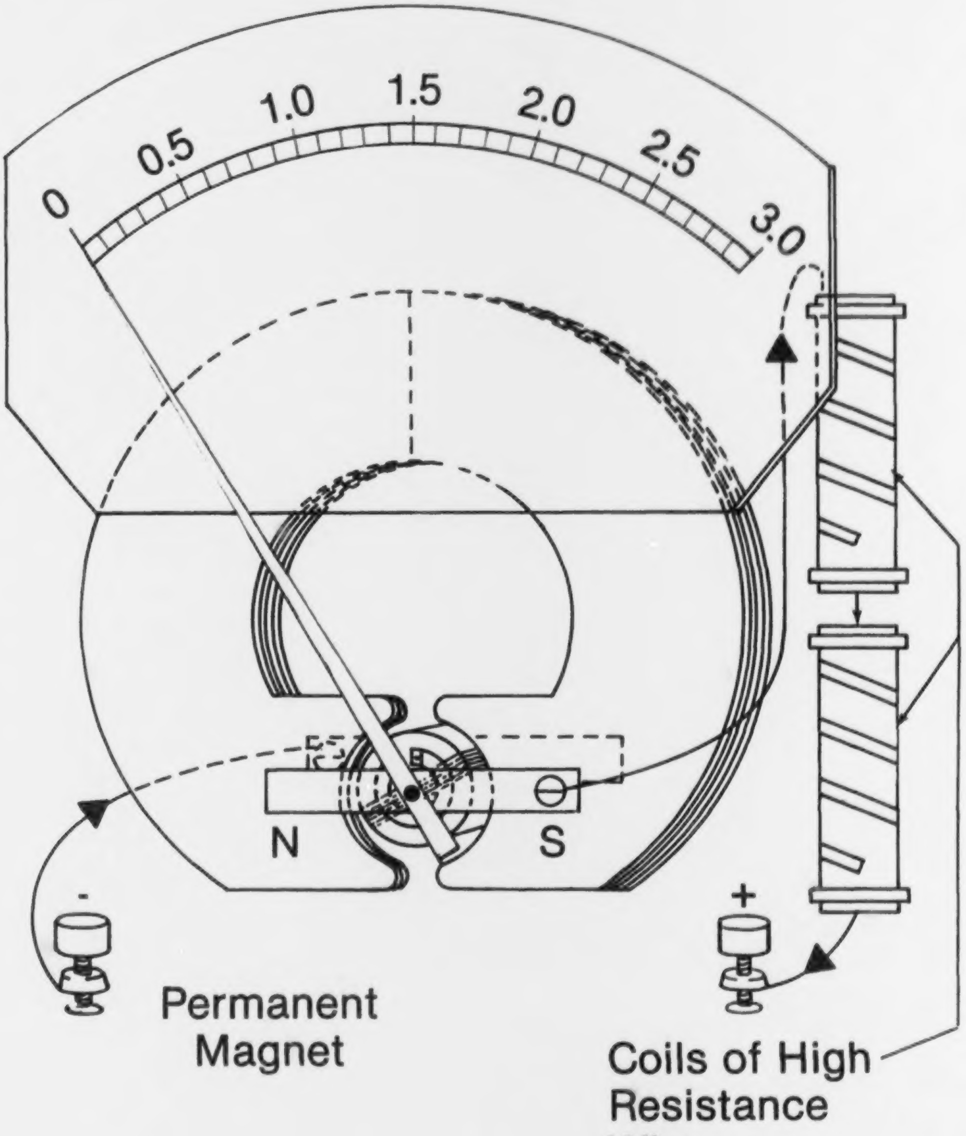
TM 24

Ammeter Operation

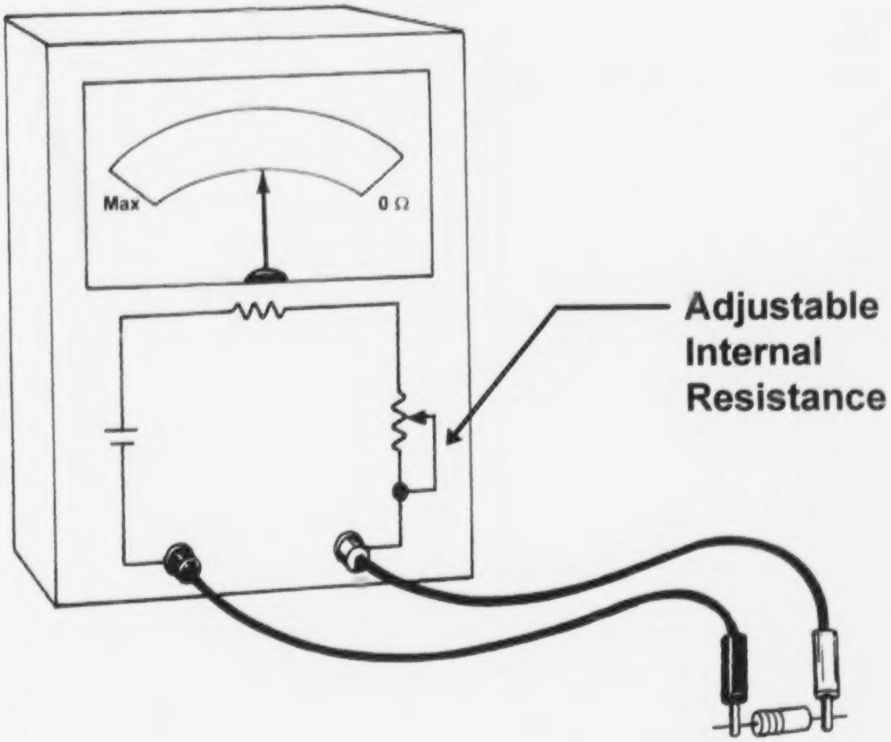

0
2
4
6
8
10
N
S
-
+
Low Resistance Shunt

TM 25

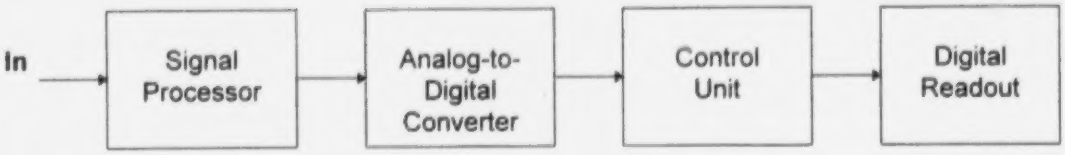
Voltmeter Operation

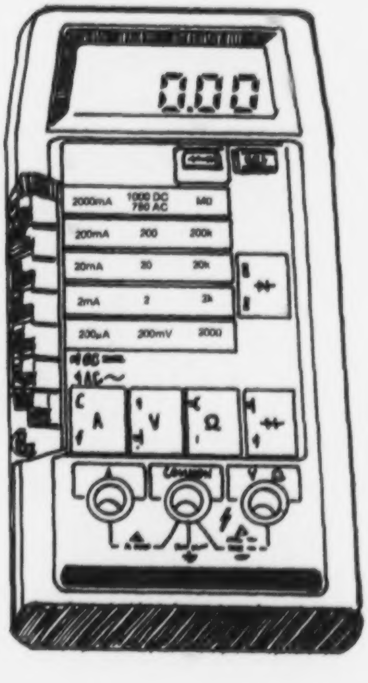

0
0.5
1.0
1.5
2.0
2.5
3.0
N
S
-
+
Permanent Magnet
Coils of High Resistance Wire

Ohmmeter Operation

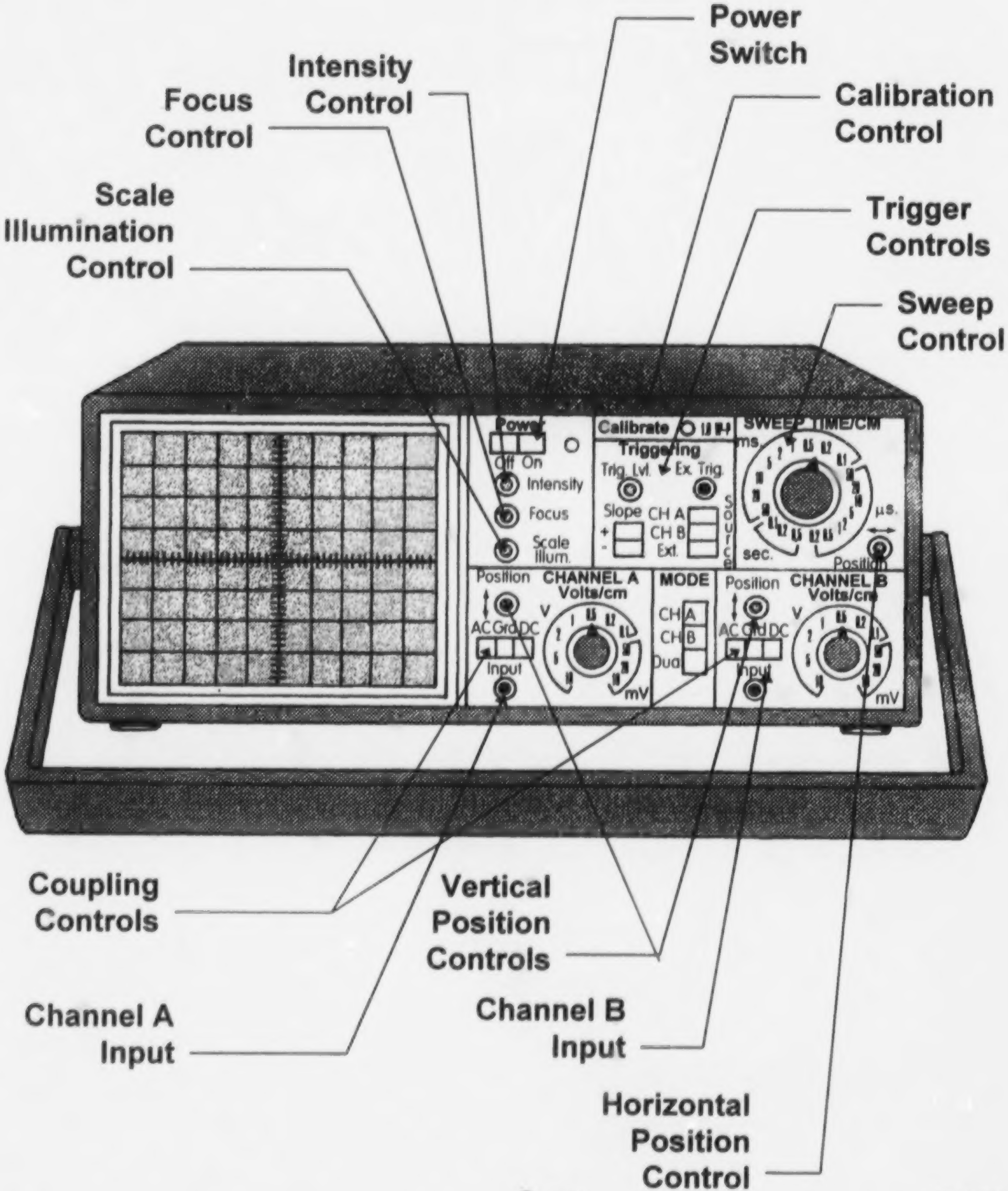

Max
0 Ω
Adjustable
Internal
Resistance

Digital Meter Functional Blocks

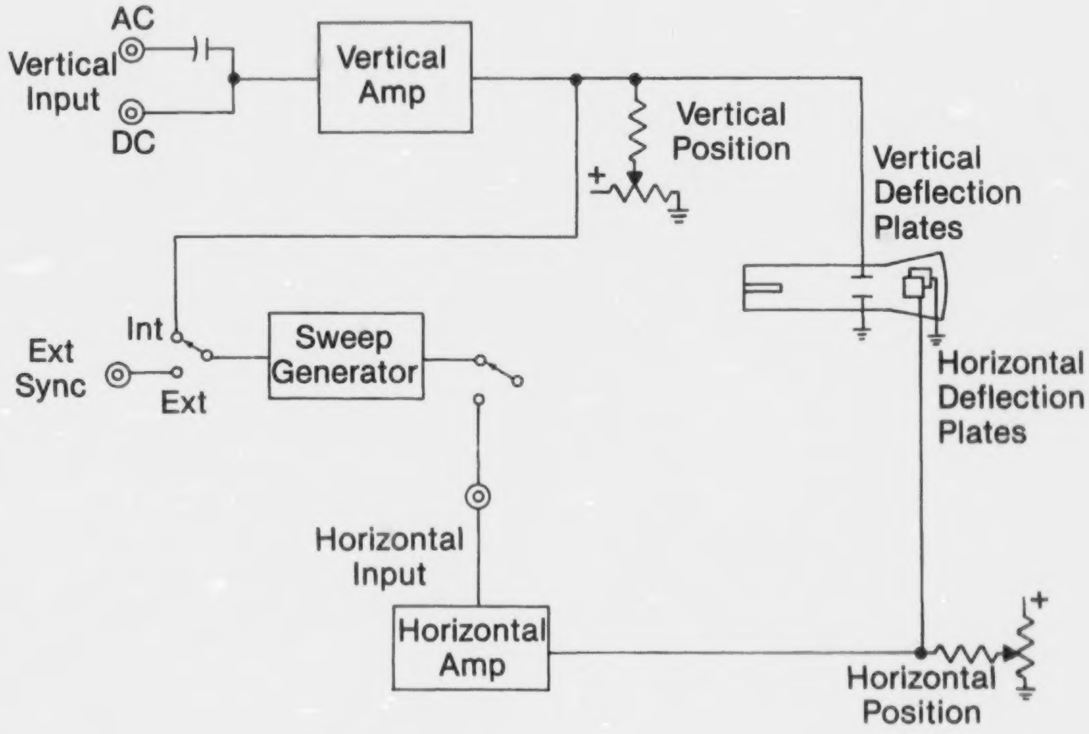

In
Signal Processor
Analog-to-Digital Converter
Control Unit
Digital Readout



Oscilloscope Controls

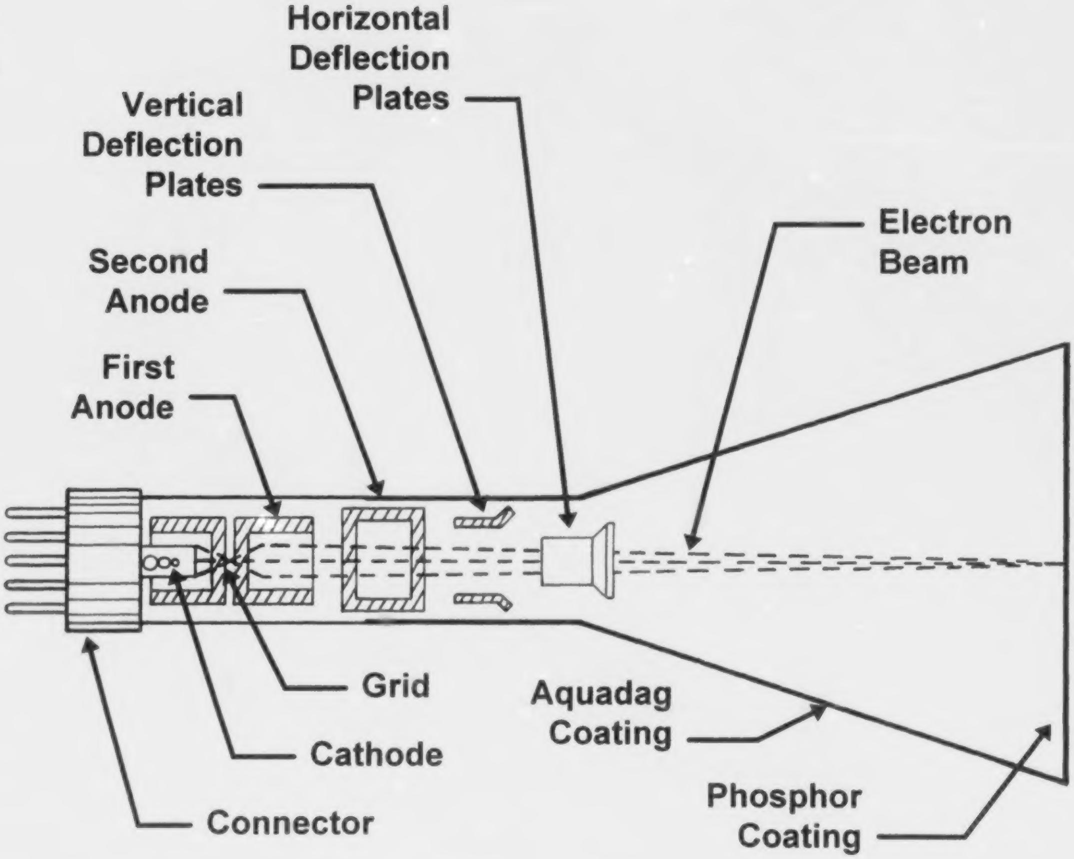

Power Switch
Intensity Control
Focus Control
Calibration Control
Scale Illumination Control
Trigger Controls
Sweep Control
Power
Off On
Intensity
Focus
Scale Illum.
Calibrate
Triggering
Trig. Lvl.
Ex. Trig.
Slope
CH A
CH B
Ext.
Source
SWEEP TIME/CM
ms.
µs.
sec.
Position
CHANNEL A Volts/cm
V
mV
AC Grd DC
Input
MODE
CH A
CH B
Dual
CHANNEL B Volts/cm
Coupling Controls
Vertical Position Controls
Channel A Input
Channel B Input
Horizontal Position Control

Oscilloscope Block Diagram


AC
Vertical Input
DC
Vertical Amp
Vertical Position
+
Vertical Deflection Plates
Int
Ext Sync
Ext
Sweep Generator
Horizontal Deflection Plates
Horizontal Input
Horizontal Amp
+
Horizontal Position

TM 30

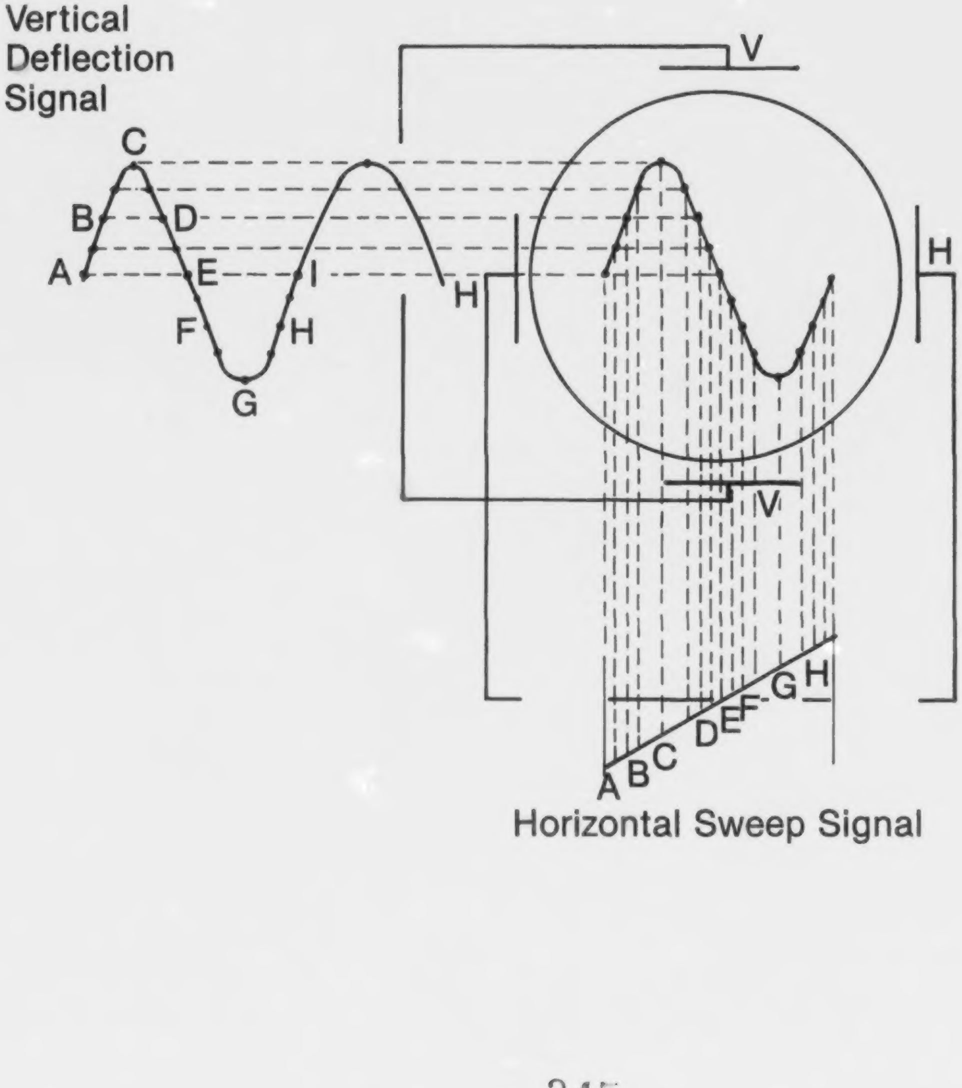
Cathode Ray Tube


Horizontal Deflection Plates
Vertical Deflection Plates
Electron Beam
Second Anode
First Anode
Grid
Aquadag Coating
Cathode
Phosphor Coating
Connector

344

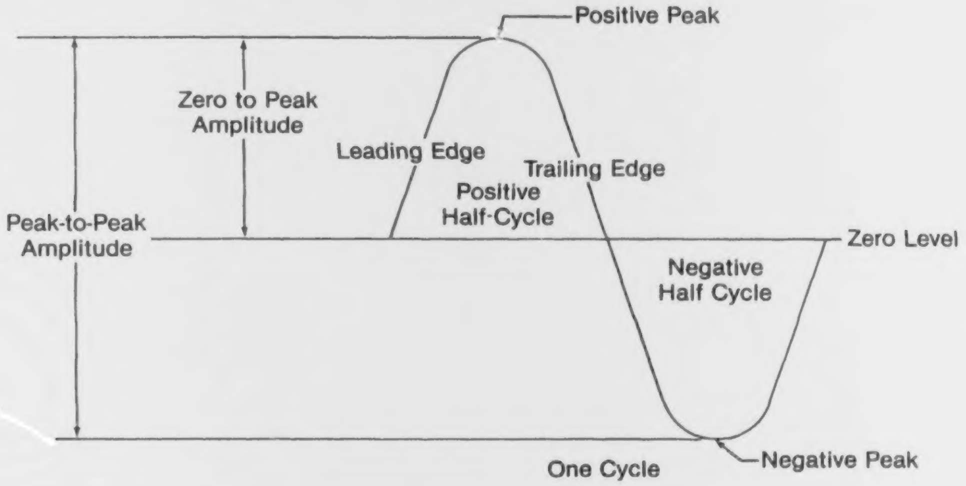
TM 31

CRT Signal Trace

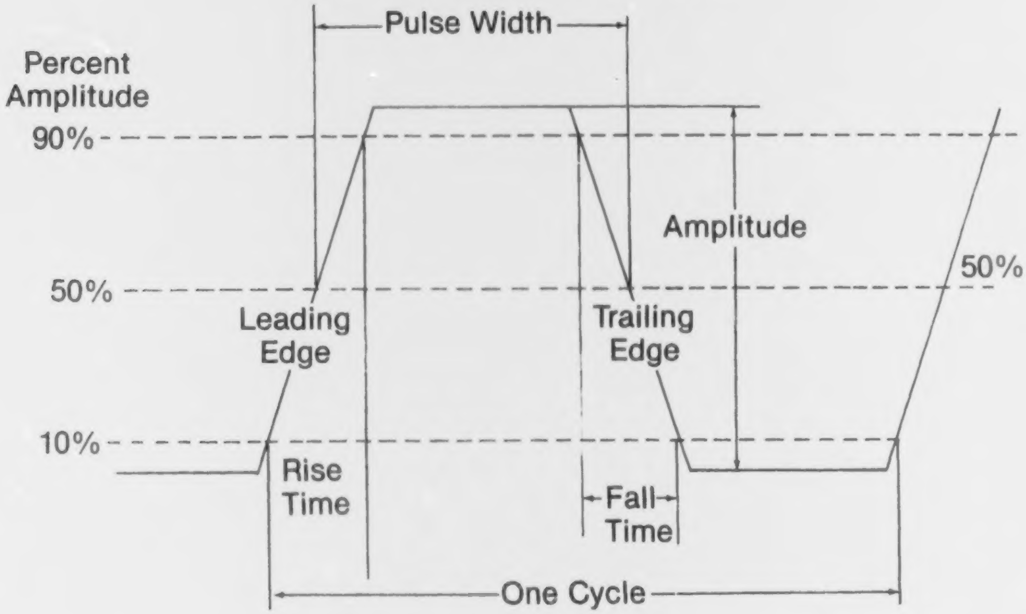

Vertical Deflection Signal
C
B
D
A
E
I
F
H
G
H
V
H
V
H
G
F
E
D
C
B
A
Horizontal Sweep Signal

Parts of a Waveform

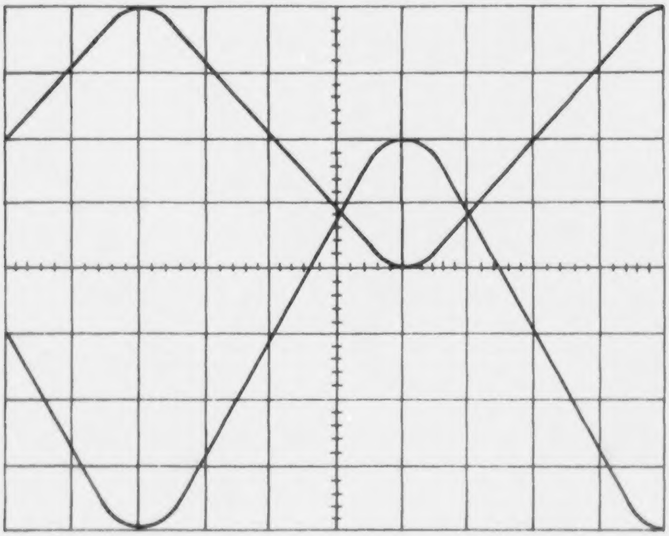
Sinusoidal Waveform


Positive Peak
Zero to Peak Amplitude
Leading Edge
Trailing Edge
Positive Half-Cycle
Peak-to-Peak Amplitude
Zero Level
Negative Half Cycle
One Cycle
Negative Peak

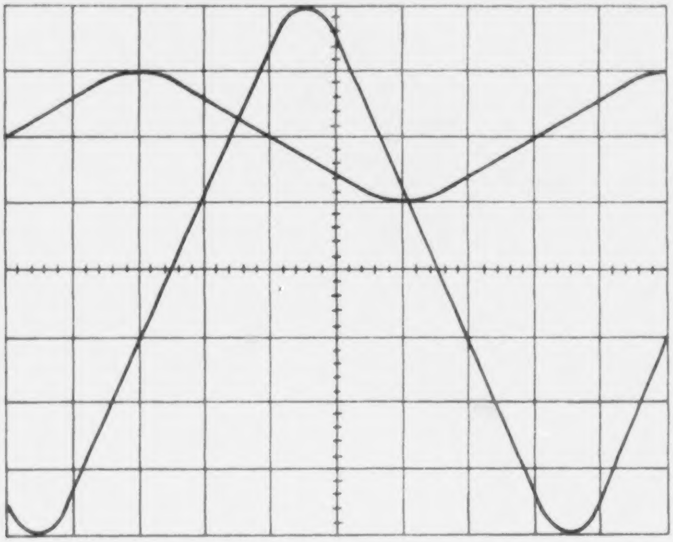
Rectangular Waveform


Pulse Width
Percent Amplitude
90%
Amplitude
50%
50%
Leading Edge
Trailing Edge
10%
Rise Time
Fall Time
One Cycle

Phase Relationships

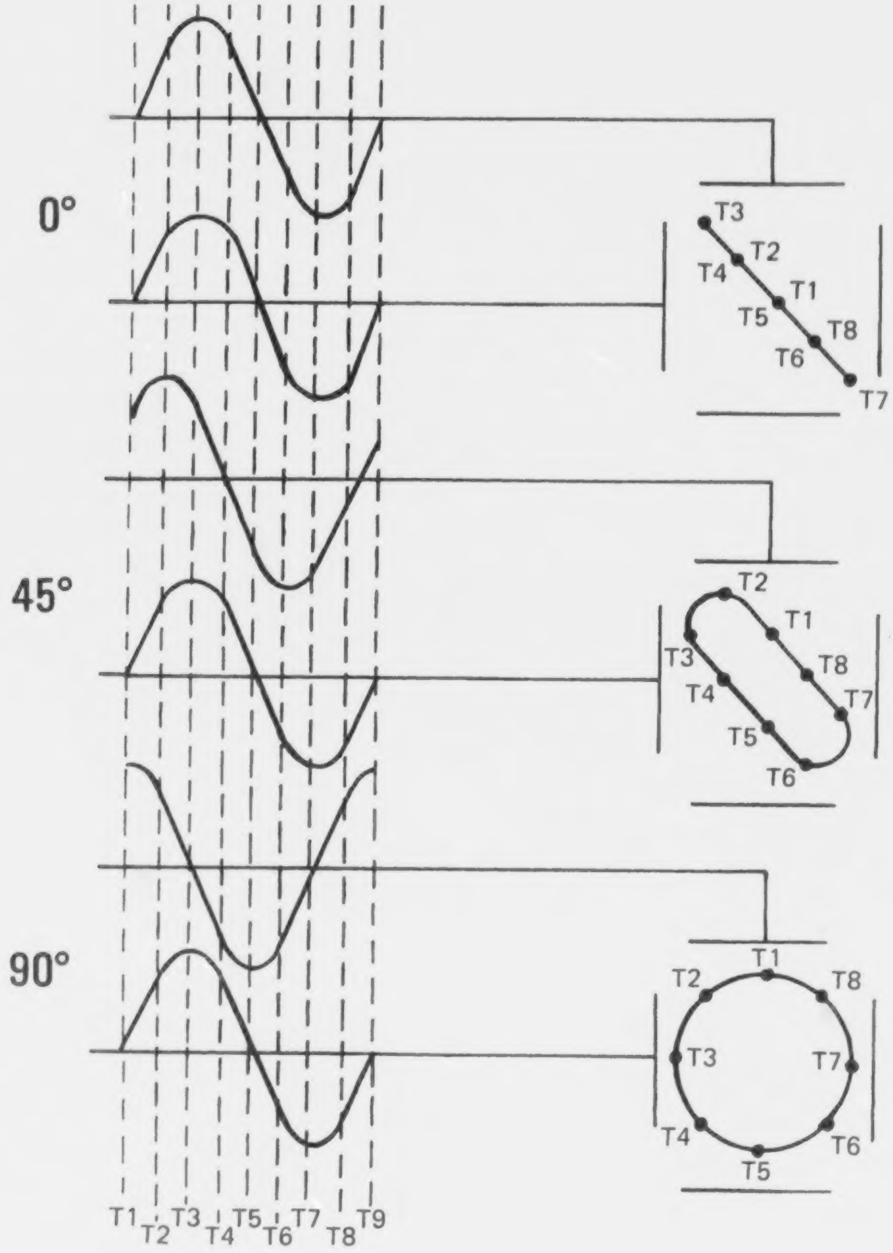


1 Cycle = 8 cm
1 cm = 45°
4 cm between Peaks
4 cm x 45° = 180°
or 180° Out of Phase



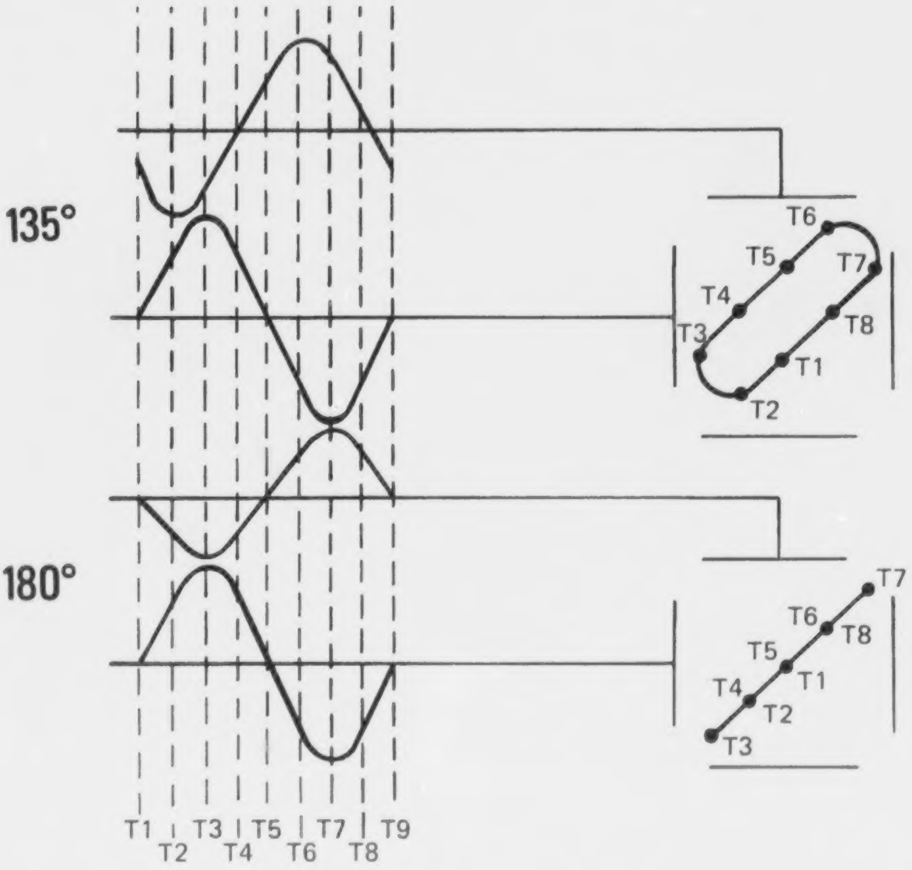
2.6 cm x 45° = 117°
or 117° Out of Phase

Lissajous Phase Patterns

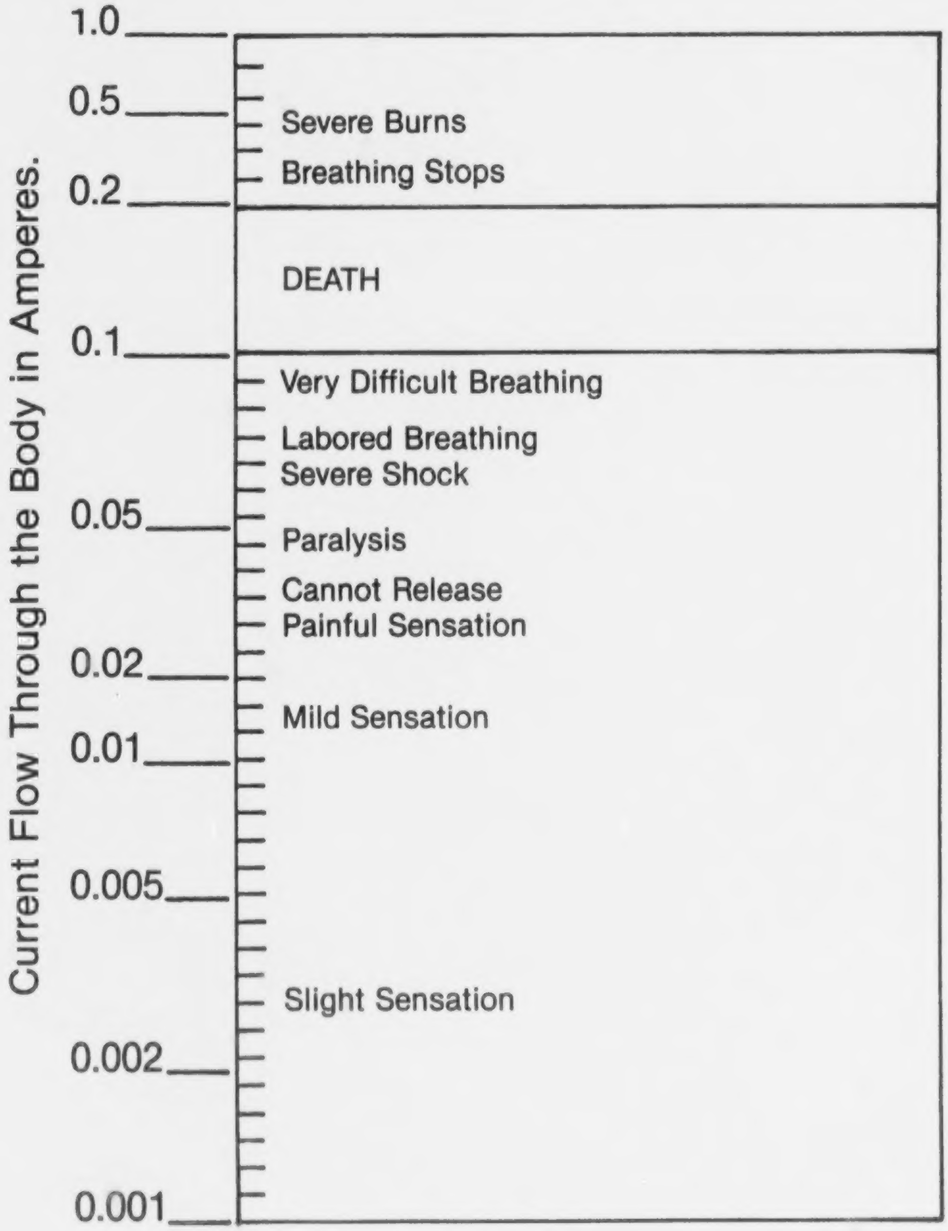

0°
T3
T2
T4
T1
T5
T8
T6
T7
45°
T2
T1
T3
T8
T4
T7
T5
T6
90°
T1
T2
T8
T3
T7
T4
T6
T5
T1
T2
T3
T4
T5
T6
T7
T8
T9

Lissajous Phase Patterns

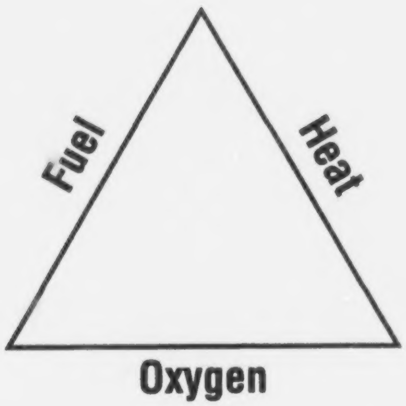
(Continued)


135°
180°
T1
T2
T3
T4
T5
T6
T7
T8
T9
T1
T2
T3
T4
T5
T6
T7
T8
T1
T2
T3
T4
T5
T6
T7
T8

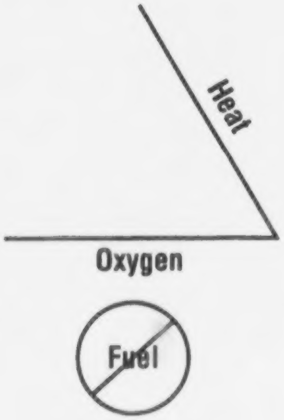
Electric Shock Versus Body Sensations

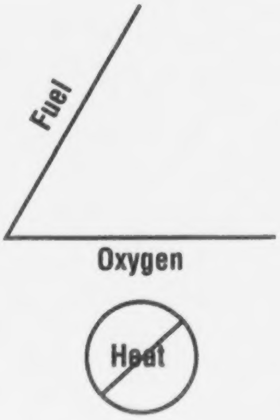


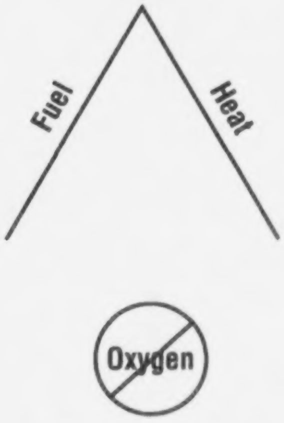
Components of the Fire Triangle


Fuel
Heat
Oxygen

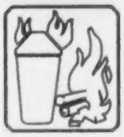
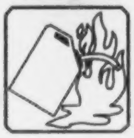
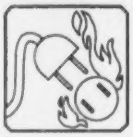
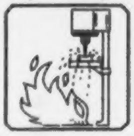
To produce fire, the three elements of the fire triangle must be present at the same time. If any one of the three is missing, a fire cannot be started. With the removal of any one element, the fire will be extinguished.


Heat
Oxygen
Fuel


Fuel
Oxygen
Heat


Fuel
Heat
Oxygen

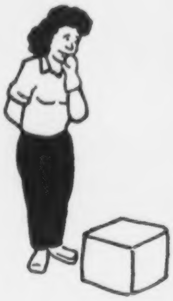
Classes of Fires and Fire Extinguisher Markings

A **Class A** (Green)  • Ordinary combustibles	B **Class B** (Red)  • Flammable liquids and gases
C **Class C** (Blue)  • Live electrical equipment	D **Class D** (Yellow)  • Combustible metals

How to Lift Safely

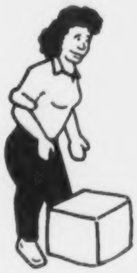
1

Approach the load and size it up as to weight, size, and shape. Consider your physical ability to handle the load.



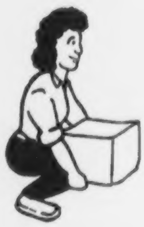
2

Place feet close to the object to be lifted and 8 to 12 inches apart for good balance.



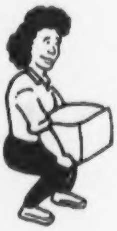
3

Bend the knees to the degree that is comfortable and get a good handhold. Then using both leg and back muscles . . .



4

Lift the load straight up smoothly and evenly. Push with your legs, and keep the load close to your body.

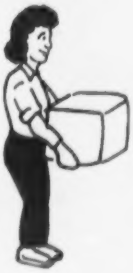


How to Lift Safely

(Continued)

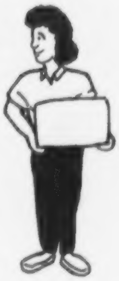
5

Lift the object into carrying position, making no turning or twisting movements until the lift is completed.



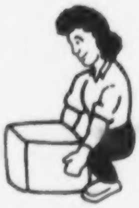
6

Turn your body with changes of foot position after looking over your path of travel, making sure it is clear.



7

Setting the load down is just as important as picking it up. Using leg and back muscles, comfortably lower load by bending your knees. When load is securely positioned, release your grip.



Fabrication and Repair
Unit 3

Suggested Activities

Instructional Plan

Preparation

- Review unit and plan presentation. Study the specific objectives to determine the order in which you will present the objectives.

  Review the unit introduction and teaching suggestions included in the delivery and application section below, and plan classroom activities. Also note the suggestions for media and supplemental materials.

  Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.

- Obtain films, videotapes, and other media to supplement instruction of this unit. See ordering information in the suggested resources section.

- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only and should be used with objectives as indicated below.

  TM 1—Types of Wires and Cables (Objective 5)
  TM 2—Types of Wires and Cables (Continued) (Objective 5)
  TM 3—Types of Connectors(Objective 6)
  TM 4—Types of Connectors (Continued)(Objective 6)
  TM 5—Soldering (Objective 12)
  TM 6—Types of Solder Joints(Objective 13)
  TM 7—Types of Solder Joints (Continued) (Objective 13)
  TM 8—Types of Solder Defects (Objective 14)
  TM 9—Types of Solder Defects (Continued) (Objective 14)
  TM 10—Desoldering (Objective 15)
  TM 11—Desoldering (Continued) (Objective 15)
  TM 12—Parts of a Printed Circuit Board (Objective 16)
  TM 13 –Types of Hole Connectors (Objective 16)
  TM 14—Troubleshooting Chart (Objective 21)
  TM 15—Block Diagram (Objective 21)

- Select teacher components (written test, unit evaluation form) you want to distribute to your students.

- Prepare classroom. Put up posters and charts and display articles and other references related to the objectives of this unit.

Suggested Activities

Delivery and Application

Unit Introduction

- Discuss unit and specific objectives.
- Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets and job sheets. Review with students the criteria for evaluation of each of these activities.

Teaching Suggestions

The skill areas appearing in bold-face type in the teaching suggestions refer to the academic and workplace skills identified in *What Work Requires of School: A SCANS Report for America 2000* and *Workplace Basics: The Skills Employers Want.* These have been adapted by MAVCC.

- Provide the students with examples of products using the various processes and materials discussed in the unit and demonstrate those processes normally performed in your facility. Show individual components and those that are installed in assemblies. **(Listening; seeing things in the mind's eye; applying technology; materials and resources)**
- Visit a facility that manufactures and repairs circuit boards, especially after the students have become somewhat familiar with the processes involved. If possible, observe both through-hole and surface-mount methods and hand and automated fabrication, as well as related processes, such as inspection, marking, testing, and conformal coating. Exhibit examples of good workmanship and examples of fabrication defects. Provide the students with examples of workmanship standards, including both commercial standards and military standards. Discuss quality assurance and invite a resource person from an electronics manufacturing facility to talk to the class about their QA program, policies, and procedures. **(Listening; science; applying technology; adapting to the organization's goals and values; monitoring systems)**
- Demonstrate desoldering methods and component removal. Discuss considerations in choosing a method, such as the cost of labor versus the costs of parts, the need for saving or not saving components or the circuit board. When demonstrating solder wick, explain the principle of capillary action. When demonstrating solder suckers and desoldering bulbs, explain how the creation of a pocket of low pressure can be used to move the solder from joints and through-holes. **(Listening; seeing things in the mind's eye; applying technology; selecting tools and procedures; materials and facilities; science)**
- If possible, visit a facility where circuit board substrates are manufactured. Display a variety of circuit board designs that use various construction methods, through-hole and surface-mount

Suggested Activities

technologies, a variety of components and connectors, etc. Invite a circuit board designer or layout person to your class to demonstrate computer-aided design tools. Exhibit drawings for substrate manufacturing and circuit board assembly. **(Listening; applying technology; adapting to the organization's goals and values)**

- Provide the students with access to the data resources available in your facility. Include a variety of print and nonprint formats if available. If possible, allow students to visit industry resource libraries on the Internet, such as those maintained by Intel, Hewlett-Packard, and others. Invite an electronics company applications engineer or sales representative to talk to the class about technical support. **(Listening; seeing things in the mind's eye; adapting to the organization's goals and values; evaluating and acquiring information; processing information)**
- Discuss troubleshooting and the skills involved in the procedure. Display examples of troubleshooting charts and tables and help the students understand how to use them. Provide the students with the opportunity to create block diagrams for electronic systems with which they are probably familiar. Use the suggested videotapes to help the students develop a systems perspective of equipment operation. Provide the students with defective equipment and guide them through the analysis process. Discuss trade-offs regarding repair or replacement of defective components and assemblies. **(Listening; adapting to the organization's values and traditional modes of operation; applying technology; maintenance and troubleshooting; problem solving; reasoning)**

Evaluation

- Discuss with students the use of the Unit Evaluation Form. Explain the rating scale that will be used for student evaluation.
- Copy written test and give to students as pretest. Record pretest score on the Unit Evaluation Form.
- Evaluate assignment sheets. See the evaluation criteria listed at the top of each assignment sheet and the component "Answers to Assignment Sheets."
- Evaluate job sheets. See the evaluation criteria listed at the top of each job sheet.
- Give and evaluate written test.
- Compile written-test, assignment-sheet, and job sheet scores on the Unit Evaluation Form. Include any additional assignments.
- Measure competency gains by comparing written pretest scores with posttest scores.

Suggested Activities

- Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas of improvement.
- Reteach and retest as required.

Instructions for Evaluating Student Performance

- When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.

Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Option A

4 — Skilled—Can perform job with no additional training.
3 — Moderately skilled—Has performed job during training program; limited additional training may be required.
2 — Limited skill—Has performed job during training program; additional training is required to develop skill.
1 — Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Suggested Activities

Suggested Resources

Resources Used in Developing This Unit

- *Basic Electronics.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1987.
- *Communications Electronics.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1988.
- Davidson, Homer L. *Troubleshooting and Repairing Compact Disc Players.* 2nd Ed. New York, New York: TAB Books, 1994.
- *Family Medical Guide.* New York, NY: Better Homes and Gardens Books, Meredith Corporation, 1993.
- *General Electronics Technician.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1987.
- *Graphic Symbols for Electrical and Electronics Diagrams.* New York: Institute of Electrical and Electronics Engineers, Inc., 1975.
- *Home Electronics.* Alexandria, Virginia: Time-Life Books, 1988.
- Reis, Ronald A. *Electronic Project Design and Fabrication.* 3rd edition. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1995.
- Roehrig, Guido and Ulrich Schueller. *Upgrading and Maintaining Your PC.* Grand Rapids, Michigan: Abacus, 1991.
- Schuler, Charles A. *Electronics Principles and Applications.* 4th edition. New York: Glencoe Division, Macmillan/McGraw-Hill School Publishing Company, 1994.
- Simpson, Colin D. *Principles of DC/AC Circuits.* Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1996.
- Villanucci, Robert S., Alexander W. Avtgis, and William Megow. *Electronics Techniques: Shop Practices and Construction.* 5th edition. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1996.

Supplemental Resources

Print Media

- Data books and resource sheets from a variety of electronics components and equipment manufacturers.
- *Electronics Workmanship Standards.* Omni Corporation.
- *Workmanship Standards.* Marietta, Georgia: Martin-Marietta Corporation.

Suggested Activities

- *Rework and Repair for Electronics.* Laurel, Maryland: Pace Incorporated.

Non-print Media

- *Connector Assembly and Connector Termination.* Shows how to fabricate common electronic connectors and cables. A 1992 release. Available from: American Association for Vocational Instructional Materials; 745 Gaines School Road; Athens, GA 30605; 800-228-4689.

- *Controlling Systems.* This program discusses macro- and microsystems and defines feedback. The discussions of monitoring devices, sensors, transducers, and comparators are basic and not overly technical and can be helpful in expanding the students' perspective of systems approaches. Available from: Bergwall Productions, Inc.

- *Electrical Troubleshooting Techniques.* Covers equipment and methods for performing electrical troubleshooting (1987). Available from: Tel-A-Train; P.O. Box 4752; Chattanooga, TN 37405; 800-266-0113.

- *High-Reliability Soldering.* This series of 18 programs covers various soldering tasks, including bifurcated terminals, connectors, turrets, surface-mount devices, through-hole, and other common electronic soldering requirements. Available from: NUS Training Corporation; 910 Clopper Rd.; Gaithersburg, MD 20878-1399; 800-848-1717.

- *The Universal Systems Model.* This 16-minute videotape can be used in helping students learn to approach troubleshooting from a systems level. It introduces the concepts of open- and closed-loop systems and presents procedures for technological problem-solving. Available from: Bergwall Productions, Inc.,

Software

- *Electronic Assembly and Soldering.* Interactive system for concepts and techniques. Available from: The Conover Company, Ltd.; P.O. Box 155; Omero, WI 54963.

Fabrication and Repair
Unit 3

Answers to Assignment Sheets

Assignment Sheet 1—Use Data Books and Other Resources

Part 1

1. 2N4402 general purpose transistor from Proton Power Products
2. A general purpose silicon transistor for use in home and light industrial systems.
3. a. -40 vdc
   b. -5 vdc
   c. -100 mA
   d. -0.6 to -1.0 vdc

4. a. 0°C to 70°C
   b. -55°C to 150°C
   c. 300°C, 10 seconds
   d. 80°C/watt
5. 25°C

Part 2

Student performance should be evaluated according to the criteria listed on the assignment sheet.

Assignment Sheet 2—Apply Troubleshooting Principles

1. b
2. c
3. a
4. d
5. c
6. c
7. a
8. d
9. d
10. b
11. c
12. a
13. c
14. c
15. b
16. d
17. d
18. c
19. d
20. d

Fabrication and Repair
Unit 3

Answers to Written Test

1.	a.	19	g.	8	m.	9	s.	14
	b.	16	h.	21	n.	17	t.	7
	c.	3	i.	6	o.	4	u.	12
	d.	11	j.	10	p.	15		
	e.	5	k.	13	q.	2		
	f.	1	l.	20	r.	18		

2.	a.	8	d.	4	g.	7
	b.	1	e.	9	h.	5
	c.	2	f.	6	i.	3

3.
   a. Stripping—Removing the insulation from wire or cable
   b. Tinning—Coating the end of a lead or wire with solder
   c. Lead-forming—Bending the lead of a component to create a certain shape
   d. Loading—Installing parts in a circuit board prior to soldering them
   e. Cleaning—Removing corrosion and contaminants from surfaces
   f. Drying (baking)—Heating a component or assembly to remove moisture from its surface
   g. Burn-in—Applying power to a part or assembly for a period of time to ensure proper operation or to eliminate parts that have a short operational life
   h. Screening—Testing parts to verify that they function or to select parts with best performance levels
   i. Scuffing—Adding a rough texture to a surface to improve bonding

4.	a.	8	d.	9	g.	5	j.	2
	b.	10	e.	7	h.	4		
	c.	1	f.	3	i.	6		

5.
   a. Solid single conductor
   b. Stranded single conductor
   c. Shielded
   d. Coaxial
   e. Twisted
   f. Twin lead
   g. Flat (ribbon) cable

6.
   a. Terminal lug
   b. Turret terminal
   c. Bifurcated terminal
   d. Threaded terminal post
   e. Ring terminal
   f. Fork terminal
   g. Blade terminal
   h. Pin terminal
   i. Socket
   j. Jack
   k. Multi-pin connector
   l. Edge connector

Answers to Written Test

7. a. Soldering—Connectors can be soldered onto wires or wires can be soldered to terminals
   b. Crimping—Connectors can be crimped onto wires
   c. Bonded—Connectors can be embedded in an assembly as part of the manufacturing process, such as edge connectors on a circuit board
   d. Encapsulated—Connectors can be inserted into a connector body which is then filled with potting compound
   e. Threaded fasteners—Connectors can be installed on an assembly with threaded fasteners or secured to a threaded terminal post with a nut
   f. Rivets—Connectors and sockets are sometimes installed on assemblies through the use of rivets
   g. Self-locking—Pins and other connectors may be self-locking and frequently require special insertion and removal tools

8. a. To align the leads with the installation area, such as the holes for a through-hole component or the adhesive pad area for a surface-mount component
   b. To improve the installation or the soldering surface, such as in clinching leads
   c. To provide stress relief

9. a. To protect the leads or wires from corrosion
   b. To improve the solderability of the lead or wire
   c. To prevent stranded wires from unraveling

10. a. To provide an electrical connection with virtually no resistance
    b. To prevent corrosion of conductors that would be exposed if not coated with solder
    c. To provide a strong mechanical connection
    d. To provide a seal to keep moisture and other contaminants out of the circuitry

11. a. Solder
    - percentage
    - bars, sheets, wire spools
    - diameter
    - cores

    b. Flux
    - corrosion
    - before, during
    - core
    - organic salt
    - medium
    - rosin
    - water

12. a, b, c, d, f, g, h, i, j, l, n, o, p, s, t, v

13. a. Butt connections
    b. Lap connections
    c. Wire hook
    d. Wire wrap
    e. Bifurcated terminal
    f. Flat-mount fillet
    g. Straight through-hole
    h. Clinched through-hole
    i. Swaged or spaded lead

Answers to Written Test

14.

a.	6	d.	2	g.	9	j.	8
b.	10	e.	3	h.	1	k.	11
c.	7	f.	4	i.	5		

15.
a. Solder wick—Use of a braided wire that allows melted solder to flow up into the braid
b. Desoldering bulb—Use of a suction device that is activated by squeezing a bulb to create low pressure that draws melted solder into the bulb
c. Solder sucker—Use of a suction device that is activated by moving a plunger to create low pressure that draws melted solder into the body of the device
d. Heat and pull—Process of applying heat with a soldering iron, hot plate, directed heat, or other source to melt the solder to allow the component to be pulled from the board
e. Clip and pull—Method in which the leads of the component are cut and then the solder joints are desoldered to allow removal of the leads
f. Solder bath—Method of applying new solder in an effort to get the new solder to mix with the old solder so that both can be removed

16.
a. Conductor runs (traces)
b. Conductor pads
c. Ground plane
d. Voltage plane
e. Unsupported holes
f. Plated through-hole
g. Eyelets (funnelets)
h. Posts
i. Terminals
j. Insulation
k. Edge connector
l. Silkscreen

17.
a. Single-sided
b. Double-sided
c. Multiple layer laminations
d. Flex circuit
e. Backplane

18.

a.	5	d.	1
b.	2	e.	4
c.	6	f.	3

19.

a.	2
b.	4
c.	5
d.	3
e.	1

20.
a. Solvents
b. Abrasives
c. Hot air
d. Thermal knives
e. Debonding agents

Answers to Written Test

21. a. 4
    b. 6
    c. 1
    d. 7
    e. 2
    f. 8
    g. 3
    h. 5

Fabrication and Repair
Unit 3

Written Test

Name ________________________ Date __________ Score __________

1. Match terms associated with fabrication and repair to their correct definitions. Write the corresponding numbers on the blanks provided.

_____ a. Type of circuit board and electronic component design in which the component leads pass through the circuit board and are soldered on the side opposite installation

_____ b. To join two similar objects at their ends, especially through the use of a third object that overlaps the first two

_____ c. Method of helping to secure a component to a circuit board by bending the lead after it has passed through the through-hole

_____ d. Process of bending or shaping component leads

_____ e. To build or manufacture

_____ f. Substance used to stick objects to each other

_____ g. Process of joining two objects together by melting part of one or both objects and allowing them to harden together

_____ h. Quality of labor used to produce an object as reflected in the product's conformity to standards

_____ i. Of parts that fit together, referring to the one with a hollow or opening into which the mating part fits

_____ j. Exposed conductor extending from an electronic component

_____ k. Product of a chemical reaction in which a substance combines with oxygen

_____ l. Systematic process for determining the cause of a malfunction in a machine or piece of equipment

_____ m. Occurring occasionally as opposed to occurring at each opportunity

1. Adhesive
2. Alloy
3. Clinch
4. Corrosion
5. Fabricate
6. Female
7. Fillet
8. Fusion
9. Intermittent
10. Lead
11. Lead-forming
12. Male
13. Oxide
14. Plating
15. Resin
16. Splice
17. Surface-mount
18. Terminal
19. Through-hole
20. Troubleshooting
21. Workmanship

Written Test

______n. Type of circuit board and electronic component design in which the components are soldered or bonded to the surface of the circuit board

______o. Chemical reaction between metals and other substances, including air, in which oxides form and the surface of the metal deteriorates

______p. Synthetic substance used as a liquid that hardens to form a tough plastic

______q. Material made by combining two or more metals, such as tin and lead to make solder

______r. Point in an electrical circuit designed to connect with another part of the circuit

______s. Process of covering an object with metal, such as covering a circuit board with solder

______t. Rounded or concave surface created at the joint between two surfaces, such as a solder joint

______u. Of parts that fit together, referring to the one with an extension that fits into the other part

2. Match methods of electronic circuitry fabrication to their correct descriptions. Write the corresponding numbers on the blanks provided.

______a. Use of mechanical devices designed in sets with matching interlocking grooves

______b. Use of an adhesive to join parts

______c. Use of pressure to deform parts to hold them together

______d. Use of sets of parts that fit together with sufficient pressure or with built-in locking devices so that they are held in place

______e. Use of tape or other flexible covering that is wound around parts or the winding of one part around another part

______f. Use of a metal alloy that is melted to form a coating over joined parts and allowed to harden

1. Bonding
2. Crimping
3. Encapsulation
4. Mating
5. Rivets
6. Soldering
7. Swaging
8. Threaded fasteners
9. Wrapping

______g. Use of specially designed components that are pressed into their locations under extreme pressure

______h. Use of metal devices that are inserted through holes and then folded over to prevent them from being pulled back through the holes

______i. Use of a special substance that is poured as a liquid into a mold that contains parts and which then hardens to encase the parts

3. Describe component and material preparation steps.

a. Stripping—______________________________

b. Tinning—______________________________

c. Lead-forming—______________________________

d. Loading—______________________________

e. Cleaning—______________________________

f. Drying (baking)—______________________________

g. Burn-in—______________________________

h. Screening—______________________________

i. Scuffing—______________________________

4. Match materials used in electronic circuitry fabrication to their correct descriptions. Write the corresponding numbers on the blanks provided.

______a. Hollow, rubbery substance that fits over parts and that decreases in diameter when heat is applied to it

______b. Bonding agent used with surface-mount components

______c. Any of various compounds used to bond parts together

______d. Soft metal alloy, usually of tin and lead, used for plating and fusing metals together

______e. Substance used to encase parts for encapsulation

______f. Synthetic material used for bonding, coating, and in the construction and repair of circuit boards and other parts

______g. Colored compounds that can be stamped, penned, brushed, or otherwise applied to parts and assemblies to identify components and their locations and to provide other information, such as manufacturer, serial number, etc.

______h. Chemical used to clean surfaces to be soldered before and during soldering and to aid the fusion process

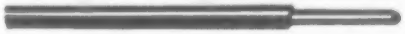
______i. Resin-based material usually containing cloth or paper for improved strength and used as an insulating base for circuit boards, bus bars, and other structures

______j. Various substances that are applied to circuit boards and other assemblies as a final sealant

1. Adhesive
2. Conformal coating
3. Epoxy resin
4. Flux
5. Ink
6. Phenolic
7. Potting compound
8. Shrink tubing
9. Solder
10. Solder paste

5. Identify types of wires and cables used in electronic circuitry fabrication.

a.



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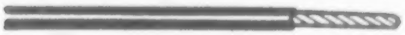
b.



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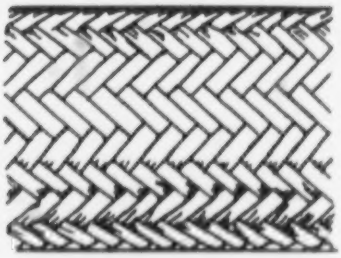
c.



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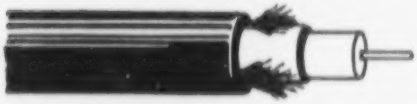
d.



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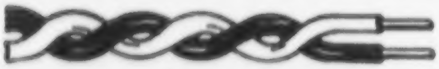
e.



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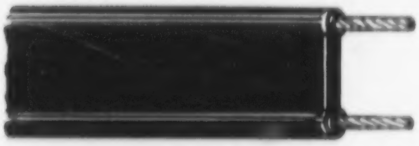
f.



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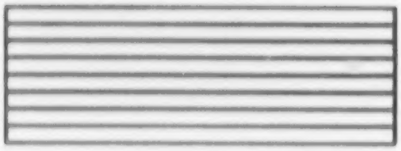
g.



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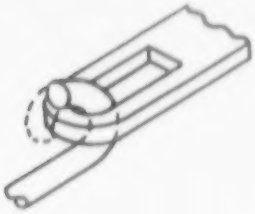
6. Identify types of connectors used in electronic circuitry fabrication.

a.



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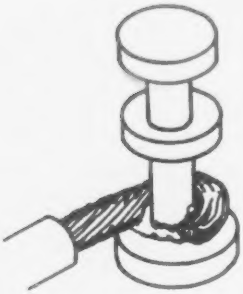
Written Test

b.



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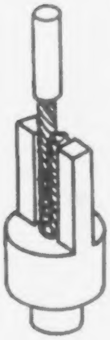
c.



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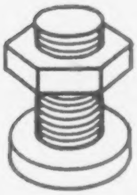
d.



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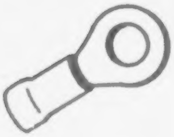
e.



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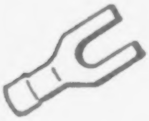
f.



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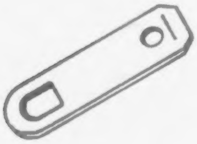
g.



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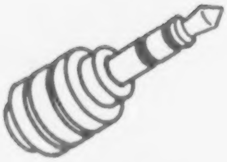
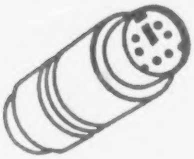
Written Test

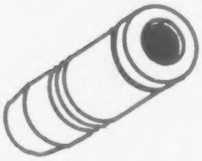
h.



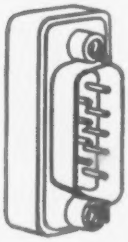
i.



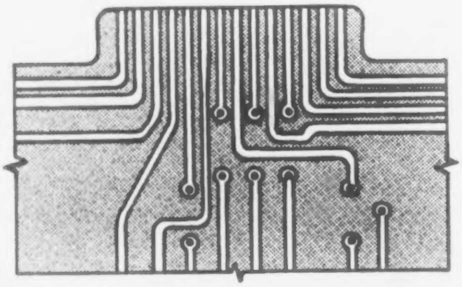
j.



k.



l.



7. Describe methods for installing connectors.

   a. Soldering—

   b. Crimping—

c. Bonded—______________________________

d. Encapsulated—______________________________

e. Threaded fasteners—______________________________

f. Rivets—______________________________

g. Self-locking—______________________________

8. List reasons for lead-forming electronic components.

a. ______________________________

b. ______________________________

c. ______________________________

9. List reasons for tinning electronic components.

a. ______________________________

b. ______________________________

c. ______________________________

10. State goals for soldered connections.

a. ______________________________

b. ______________________________

c. ____

____

d. ____

____

11. Complete statements about solder and flux.

    a. Solder

    - Generally classed by its ____________ of tin versus lead
    - Available in ____________, ____________, ____________, and special shapes, such as pellets or washers
    - Wire spool solders are classed by their ____________ and are commonly used for hand soldering
    - Wire spool solders may contain ____________, special chemicals in a hollow space within the solder, with the most common being acid or rosin fluxes

    b. Flux

    - A chemical agent that removes the __________ (oxide) films that form on metal surfaces that are exposed to air and humidity
    - Applied by hand ____________ or ____________ soldering
    - Flux is contained in the ____________ of some wire spool solders
    - ____________ (chloride) fluxes are the strongest oxide removers
    - Organic acid or base fluxes are ____________ strength oxide removers and allow fast soldering
    - ____________ fluxes are medium strength oxide removers but do not become effective until heated, thus allowing good control
    - ____________-based fluxes are low to medium strength oxide removers and tend to be more environmentally safe

12. Select from a list correct guidelines for proper hand soldering. Write an "X" in the space beside each statement below that is a correct guideline for hand soldering.

_____a. Follow guidelines for the specific soldering task.

_____b. Maintain the soldering facility as a clean, dust-free environment with a relative humidity of 30-65% and a temperature of 65-85°F (20-30°C).

Written Test

_______c. Use the proper size and shape of tip for the job to be done.

_______d. Use a solder that is suitable for the job.

_______e. Heat the solder in an oven or on a hot plate prior to use.

_______f. Use the proper temperature for the solder and type of installation.

_______g. Tin the tip of the soldering iron to help with heat transfer.

_______h. Clean the area to be soldered with flux.

_______i. Hold the tip of the soldering iron at the point to be soldered.

_______j. Hold solder against the point to be soldered on the opposite of the lead or component from the soldering iron tip.

_______k. Use medium to hard pressure to push the solder against the soldering iron to accelerate the melting process.

_______l. Allow the solder to melt and flow smoothly into the solder joint area.

_______m. Keep to a minimum the time that the soldering iron is in contact with the component, generally no more than 3 minutes per application.

_______n. Examine the solder joint and remove the solder if the joint is unacceptable.

_______o. Periodically remove excess solder from the soldering iron tip with a damp sponge.

_______p. Install components as required by the drawing and other standards, including correct polarity, correct location, and correct lead forming.

_______q. Coat the leads of the components with a good quality lubricant to help improve the solderability.

_______r. Clinch all component leads to improve the mechanical bond until the solder is applied and then straighten leads as required prior to soldering.

_______s. Use as little solder as possible while still making a satisfactory connection and remove excess solder.

_______t. Clean the soldered area(s) when soldering is complete.

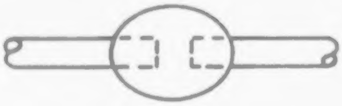
_______u. Leave the soldering equipment on around the clock to avoid having to wait for the equipment to warm up to operating temperature.

_______v. Wash your hands immediately after soldering and particularly before eating, drinking, or smoking.

Written Test

13. Identify solder joints.

a.



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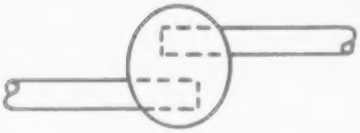
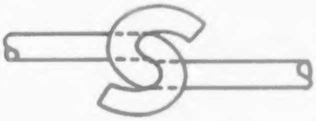
b.



____

c.



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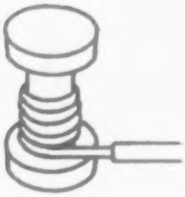
d.



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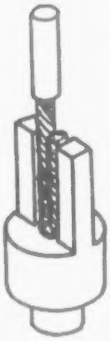
e.



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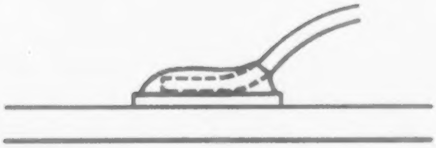
f.



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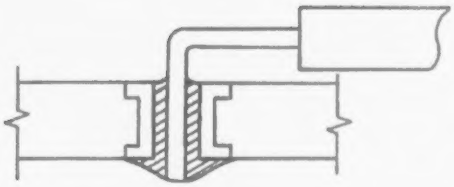
Written Test

g.



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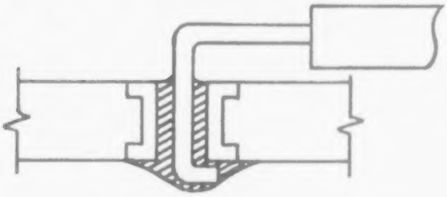
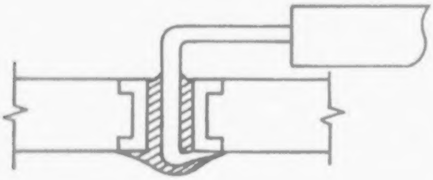
h.



____

i.



____

14. Match types of solder defects to their correct descriptions. Write the corresponding numbers on the blanks provided.

_______a. Small hole in the surface of the solder

_______b. Hollow area in joint without solder

_______c. Excess solder that rises above the intended solder joint

_______d. Excess solder that forms a short between two conductors

_______e. Amount of solder in joint does not provide a good electrical or a good mechanical bond or does not fill required connection area

_______f. Separation of a solder pad on a circuit board, usually as a result of excessive heat during soldering or desoldering or excessive physical pressure during component removal

_______g. Visible or invisible damage to a component or assembly as a result of excessive heat during soldering

1. Bird cage
2. Bridge
3. Inadequate solder or flow
4. Lifted pad
5. Measling
6. Pin hole
7. Peak
8. Poor wetting
9. Thermal damage
10. Void
11. Wicking

_____h. Condition of stranded wire conductor in which the wires have separated in or above the solder joint

_____i. Breakdown of the surface of a circuit board, often creating pockmarks on the board and usually resulting from excessive heat during soldering (especially wave soldering) or exposure to strong chemicals such as harsh organic salt fluxes

_____j. Solder does not flow evenly on a surface or does not hold together

_____k. Condition in which solder or flux travels up a wire and under the insulation

15. Describe methods for removing installed components.

a. Solder wick—____

____

b. Desoldering bulb—____

____

c. Solder sucker—____

____

d. Heat and pull—____

____

e. Clip and pull—____

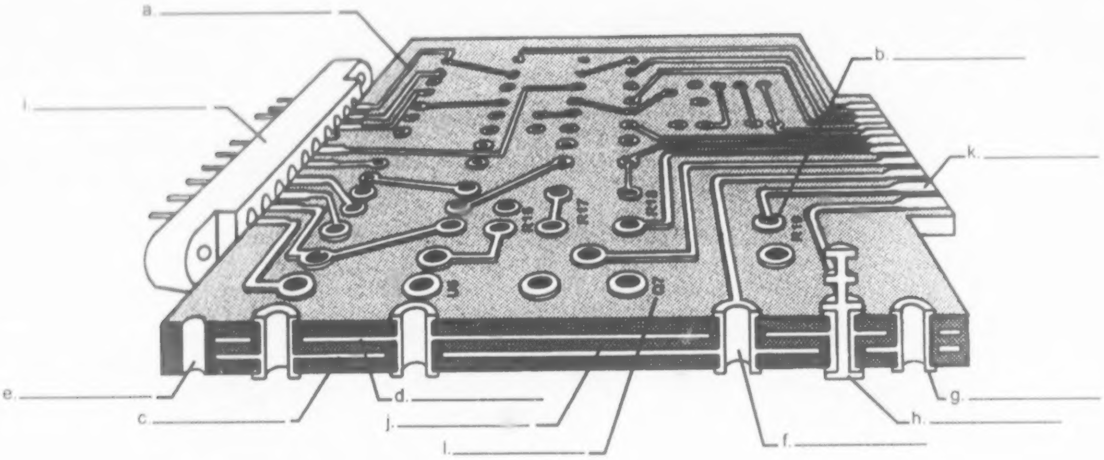
____

f. Solder bath—____

____

Written Test

16. Label the parts of a printed circuit board.



17. List types of printed circuit board construction.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

18. Match types of printed circuit board materials to their correct descriptions. Write the corresponding numbers on the blanks provided.

_____a. Rigid material made of cotton or paper impregnated with resin and suitable for moderate temperature applications

_____b. Rigid material made of glass fibers embedded in epoxy resin and generally assembled as laminated layers

_____c. Rigid material made of resins and often assembled as laminated layers

_____d. Slightly flexible material made of clays

_____e. Flexible material made of synthetic plastics

1. Ceramic
2. Epoxy glass
3. Metal plate
4. Mylar
5. Phenolic resin
6. Polyimide

______f. Flexible plates made of conductive metals such as copper and generally used with other materials as a laminated layer

19. Match printed circuit board coatings to their correct descriptions. Write the corresponding numbers on the blanks provided.

______a. Compound of carbon and oxygen in specially bonded molecules; provides good seal with moderate use today

______b. Compound of synthetic rubbers; widely used today due to good sealing properties and ability to vary application thickness

______c. Compound of synthetic rubbers; used in specific applications such as coating modules on the circuit board rather than coating the entire circuit board

______d. Synthetic plastic that produces thin, hard coating; popular for many electronic applications

______e. Compound of hydrogen cyanide and acetylene; early coating with limited use today in mild environment applications

1. Acrylic varnish
2. Epoxy resin
3. Paralene
4. Polyurethane
5. Silicone

20. List methods of removing printed circuit board coatings.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

21. Arrange in order the general steps for troubleshooting. Write the number of each step listed below in the space provided. Begin with "1" for the first step and continue numbering the steps in order.

______a. Analyze the symptoms (including any visible signs that were found) in terms of the block diagram to determine which section of the equipment is the most likely source of the symptoms.

______b. Test suspected bad components or replace suspected bad components with known-good components to verify operation.

Written Test

______c. Inspect the equipment for any visible indications of a problem, such as a loose power cord, scorched areas, melted components, loose connectors, broken solder joints, etc.

______d. If the malfunction is intermittent or does not appear during testing, it may be necessary to change the test conditions, such as applying heat or coolant to re-create the conditions under which the problem was observed.

______e. List the symptoms of malfunctioning and confirm the extent to which the malfunctions exist.

______f. Once the problem has been isolated, evaluate the costs of repairing the equipment versus replacing it and the costs and convenience of various repair options to determine a course of action.

______g. Refer to the equipment block diagram or, if no block diagram is available, create a block diagram based on your best understanding of how the equipment operates.

______h. Begin testing that section of the equipment, starting at the output and working back toward the input.

*Permission to duplicate this test is granted.

Fabrication and Repair
Unit 3

Unit Evaluation Form

Student Name ______________________ Unit Rating ______________

Assignment Sheet Ratings

Assignment Sheet 1—Use Data Books and Other Resources Rating _____

Comments: ____

____

Assignment Sheet 2—Apply Troubleshooting Principles Rating _____

Comments: ____

____

Job Sheet Ratings

Job Sheet 1—Prepare a Soldering Iron Tip for Use Rating _____

Comments: ____

____

Job Sheet 2—Adjust Wire Strippers Rating _____

Comments: ____

____

Job Sheet 3—Cut and Strip Low-Voltage Wire and Cable Rating _____

Comments: ____

____

Job Sheet 4—Install Coaxial Cable Connectors Rating _____

Comments: ____

____

Job Sheet 5—Install Ribbon Cable Connectors Rating _____

Comments: ____

____

Unit Evaluation Form

Job Sheet 6—Install Crimp Connectors on Wires Rating ______

Comments: ______________________________

____

Job Sheet 7—Install Soldered Connectors on Wires Rating ______

Comments: ______________________________

____

Job Sheet 8—Solder Wires to Turret Terminals and Desolder Wires Rating ______

Comments: ______________________________

____

Job Sheet 9—Splice Wires Together by Means of Crimping Rating ______

Comments: ______________________________

____

Job Sheet 10—Splice Wires Together by Means of Soldering Rating ______

Comments: ______________________________

____

Job Sheet 11—Install Components Using Mechanical Fasteners Rating ______

Comments: ______________________________

____

Job Sheet 12—Install Components Using Swaging Rating ______

Comments: ______________________________

____

Job Sheet 13—Form and Tin Leads on Through-Hole Components Rating ______

Comments: ______________________________

____

Job Sheet 14—Install Through-Hole Components on a Circuit Board Rating ______

Comments: ______________________________

____

Unit Evaluation Form

Job Sheet 15—Install Surface-Mount Components on a Circuit Board Rating ______

Comments:____

____

Job Sheet 16—Remove Through-Hole Components from a Circuit Board Rating ______

Comments:____

____

Job Sheet 17—Remove Surface-Mount Components from a Circuit Board Rating ______

Comments:____

____

Job Sheet 18—Repair a Printed Circuit Board Rating ______

Comments:____

____

Job Sheet 19—Inspect an Electronic Circuit and Identify Soldering and Fabrication Defects Rating ______

Comments:____

____

Written-Test Scores

Pretest ______ Posttest ______ Other ______

Other____

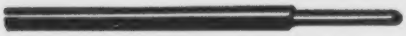
____

Teacher Signature ______________________ Date ______________

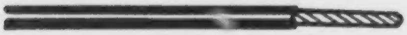
Student Signature ______________________ Date ______________

***Permission to duplicate this form is granted.**

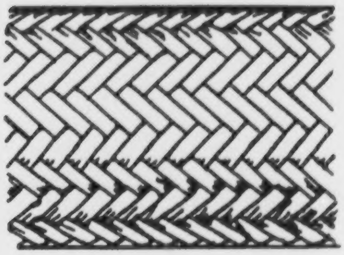
Types of Wires and Cables



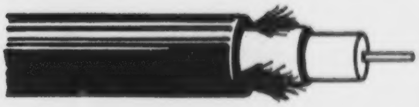
Solid single conductor



Stranded single conductor

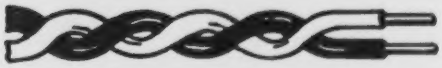


Shielded

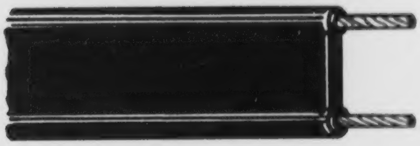


Coaxial

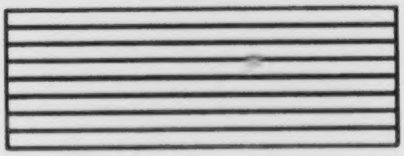
Types of Wires and Cables (Continued)



Twisted

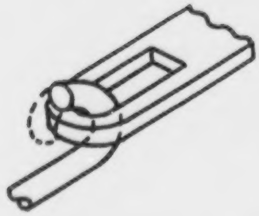


Twin lead

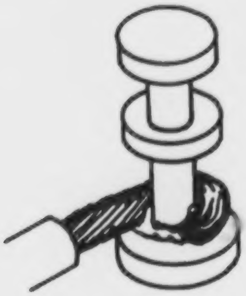


Flat cable

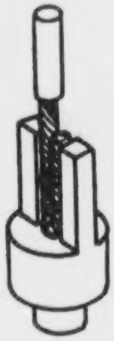
Types of Connectors



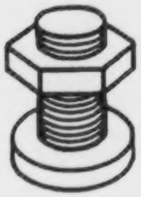
Terminal lug



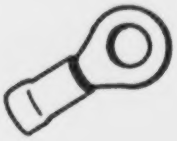
Turret terminal



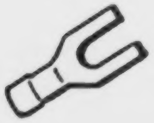
Bifurcated terminal



Threaded terminal post

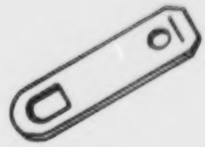


Ring terminal

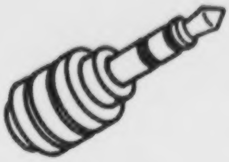


Fork terminal

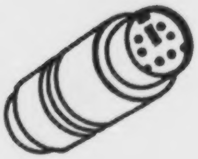
Types of Connectors (Continued)



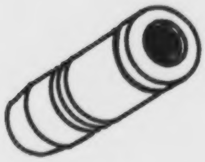
Blade terminal



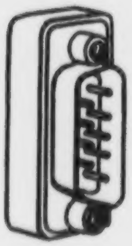
Pin terminal



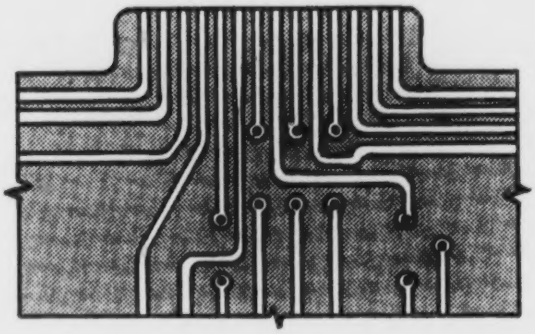
Socket



Jack

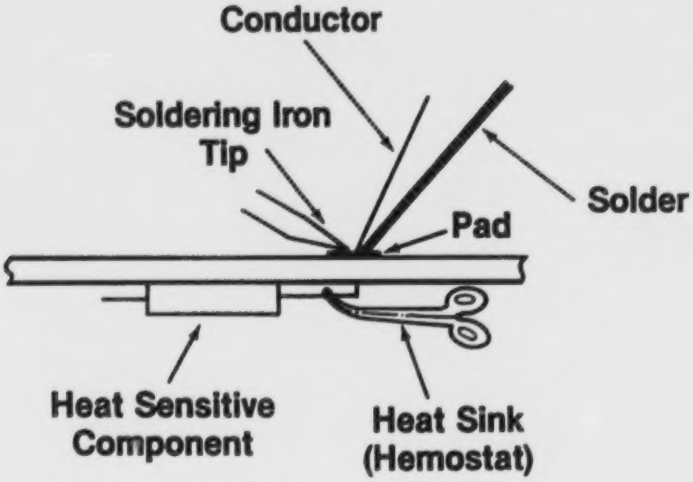


Multi-pin connector



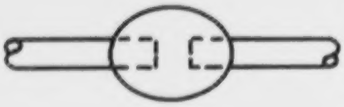
Edge connector

Soldering

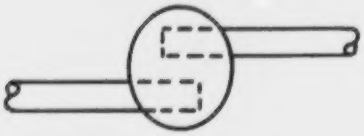

Conductor
Soldering Iron Tip
Solder
Pad
Heat Sensitive Component
Heat Sink (Hemostat)

Soldering With Heat Sink

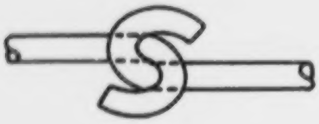
Types of Solder Joints



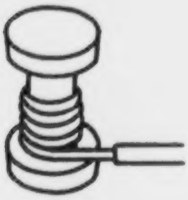
Butt connections



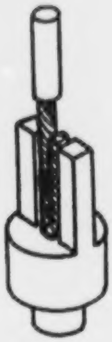
Lap connections



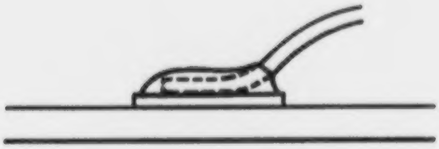
Wire hook



Wire wrap

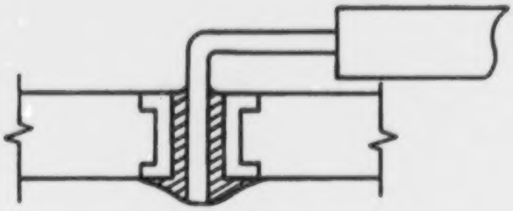


Bifurcated terminal

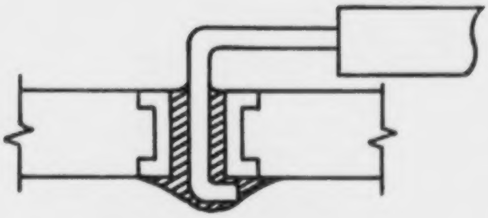


Flat mount fillet

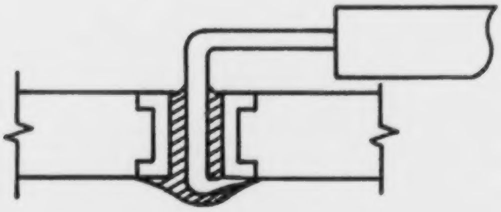
Types of Solder Joints (Continued)



Straight through-hole



Clinched through-hole

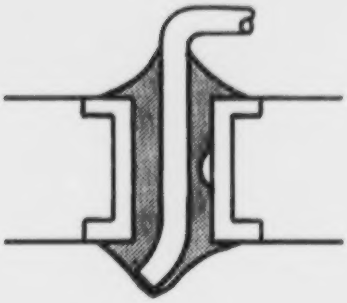


Swaged or spaded lead

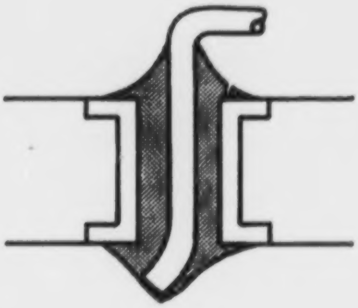
391

TM 7

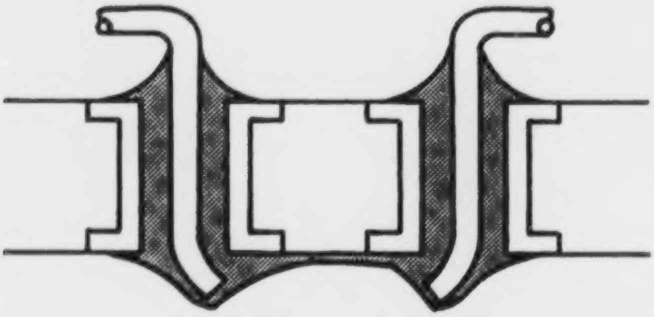
Types of Solder Defects



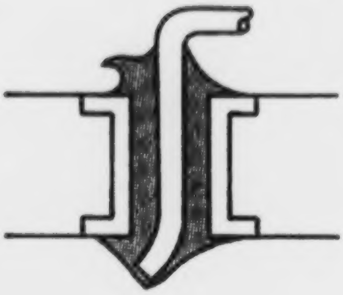
Void



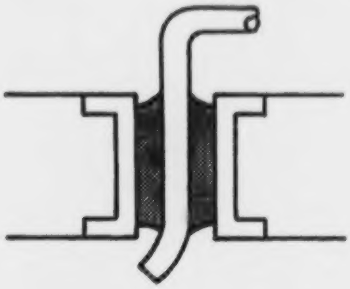
Pinhole



Bridge

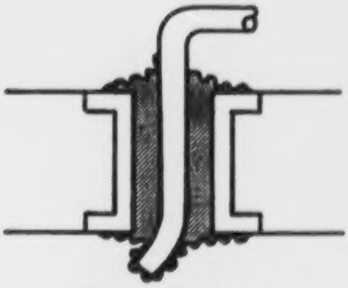


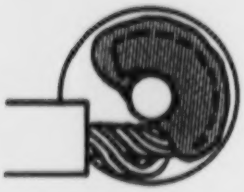
Peak

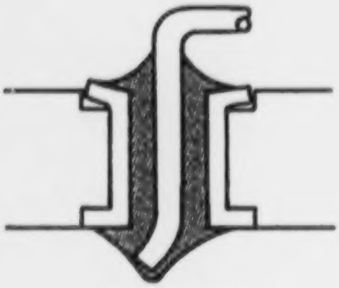


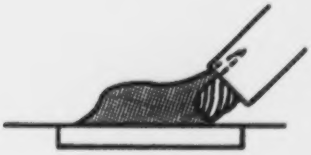
Inadequate Solder

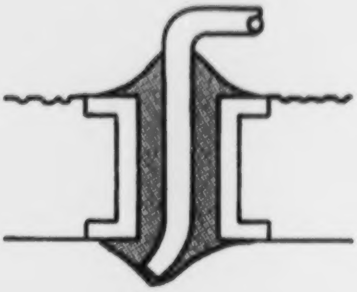
Types of Solder Defects (Continued)

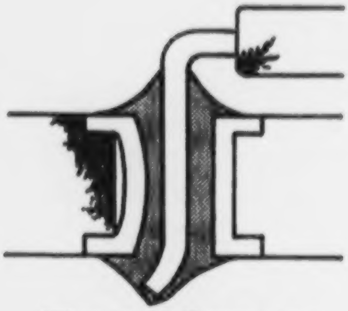

Poor Wetting


Birdcage

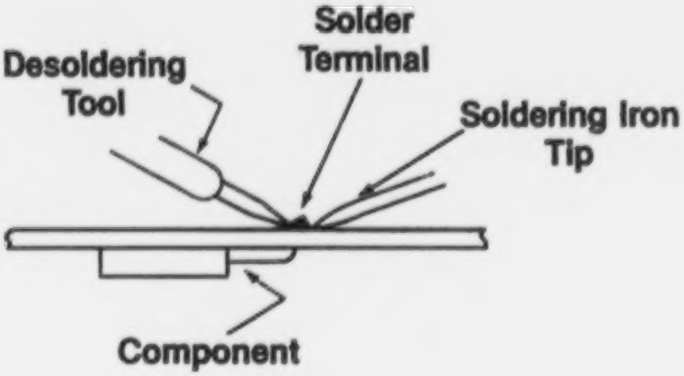

Lifted Pad


Wicking

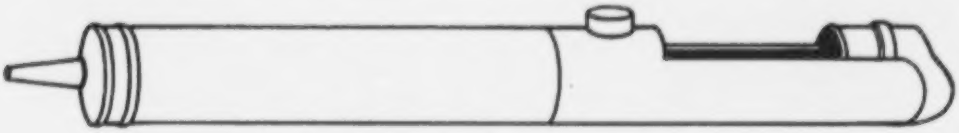

Measling


Thermal Damage

Desoldering

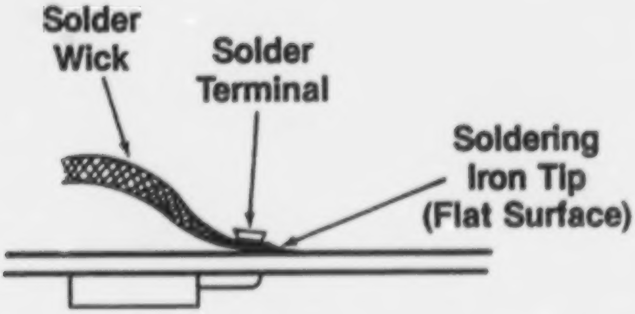

Solder Terminal
Desoldering Tool
Soldering Iron Tip
Component

Desoldering with Vacuum



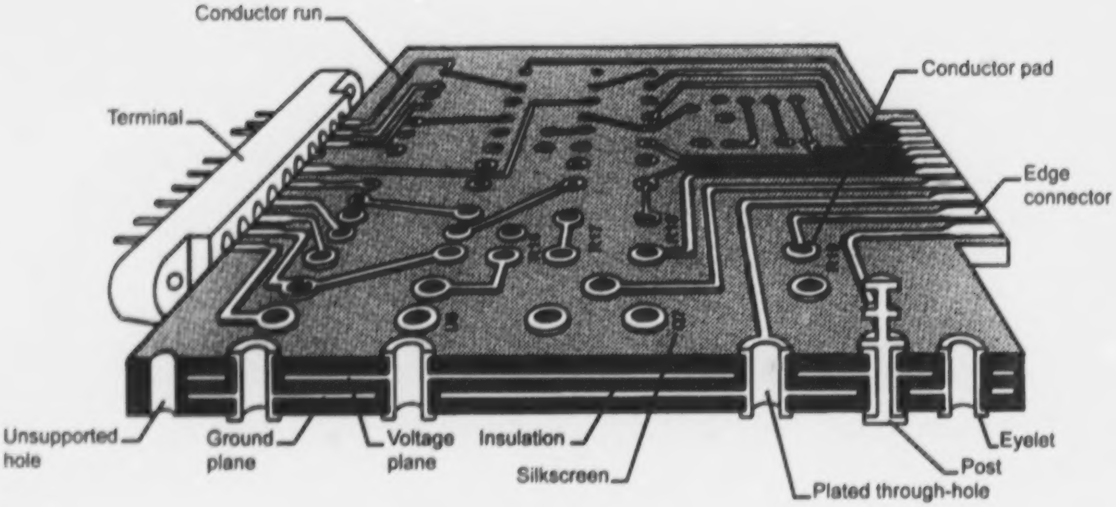
Desolder Vacuum

Desoldering (Continued)

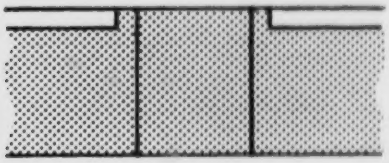

Solder Wick
Solder Terminal
Soldering Iron Tip (Flat Surface)

Desolder with Solder Wick

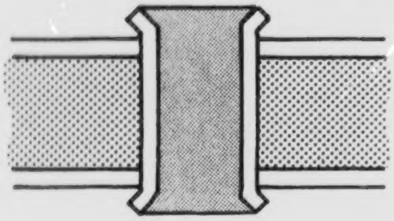
Parts of a Printed Circuit Board


Conductor run
Terminal
Conductor pad
Edge connector
Unsupported hole
Ground plane
Voltage plane
Insulation
Silkscreen
Plated through-hole
Post
Eyelet

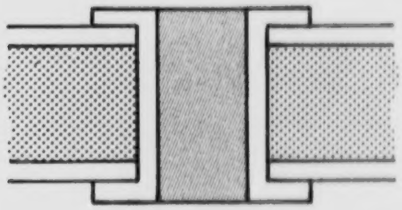
Types of Hole Connectors



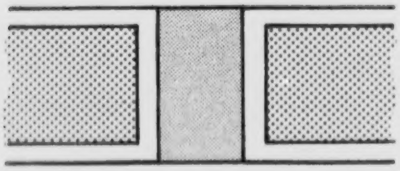
Unsupported



Funnelet

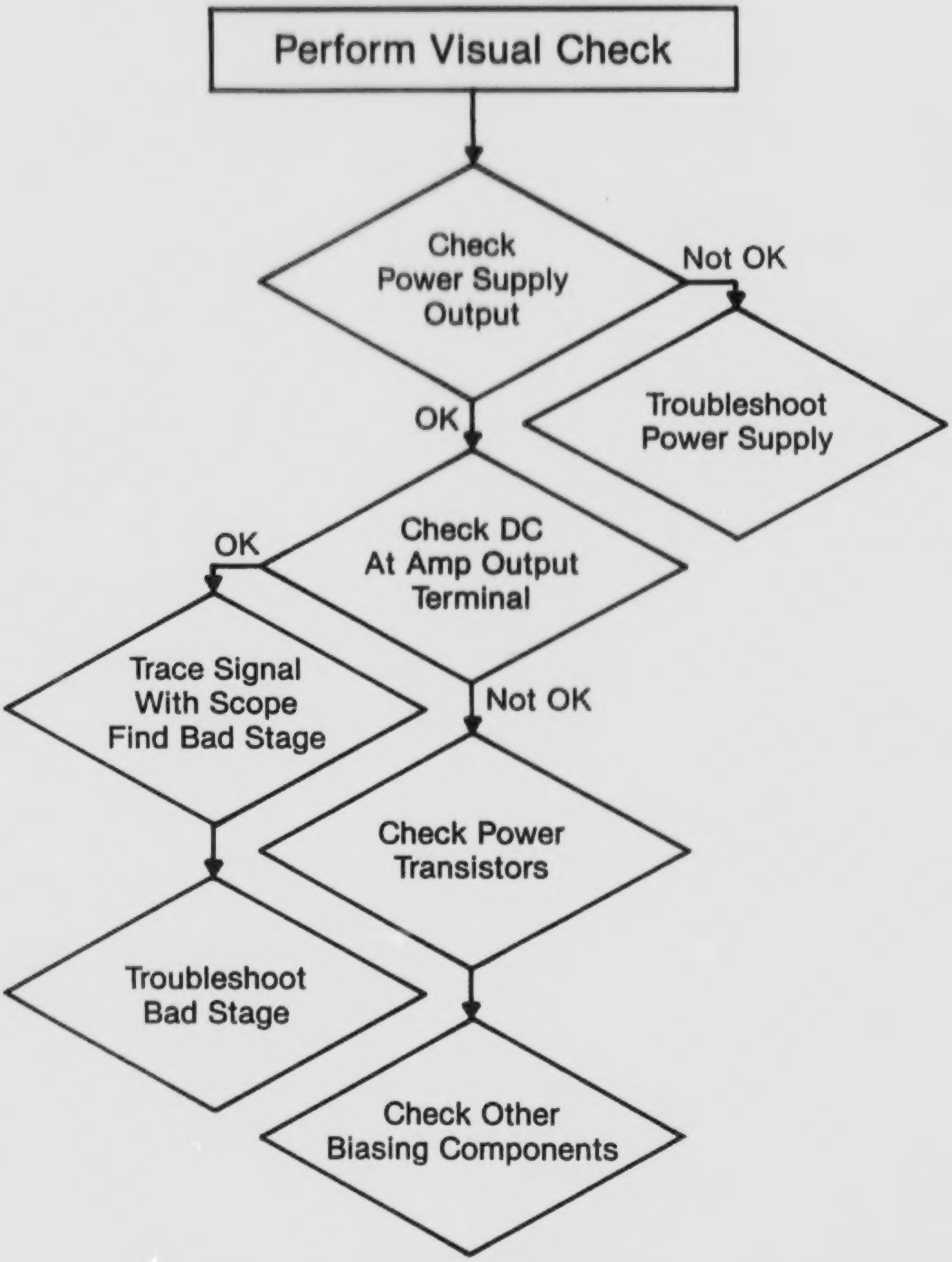


Eyelet



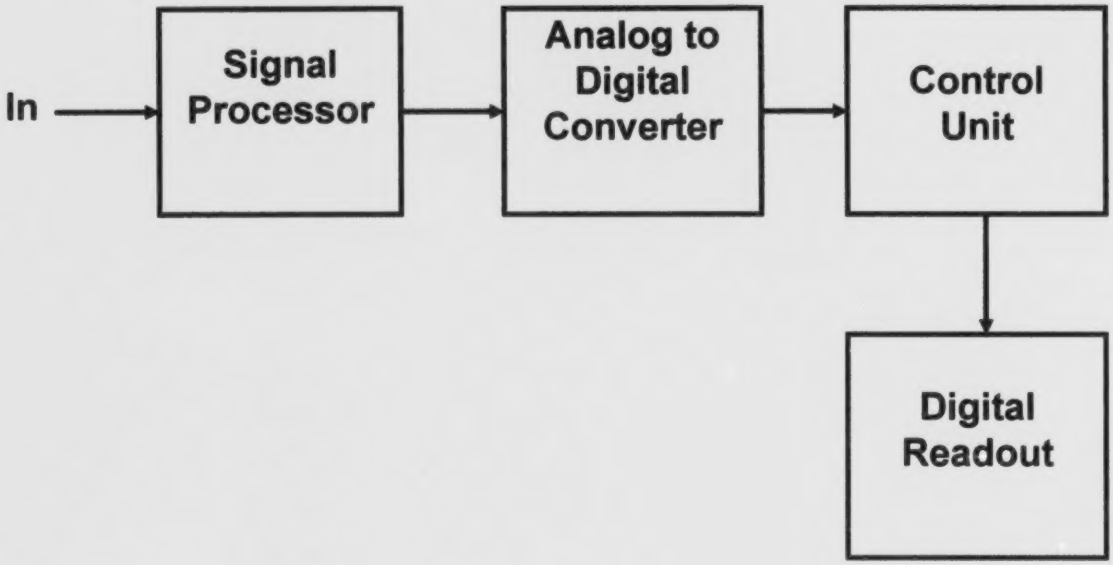
Plated through-hole

Troubleshooting Chart


Perform Visual Check
Check Power Supply Output
Not OK
Troubleshoot Power Supply
OK
Check DC At Amp Output Terminal
OK
Trace Signal With Scope Find Bad Stage
Not OK
Check Power Transistors
Troubleshoot Bad Stage
Check Other Biasing Components

TM 14

Block Diagram



In

Signal Processor

Analog to Digital Converter

Control Unit

Digital Readout

DC and DC Circuits
Unit 4

Suggested Activities

Instructional Plan

Preparation

- Review unit and plan presentation. Study the specific objectives to determine the order in which you will present the objectives.

  Review the unit introduction and teaching suggestions included in the delivery and application section below, and plan classroom activities. Also note the suggestions for media and supplemental materials.

  Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.

- Obtain films, videotapes, and other media to supplement instruction of this unit. See ordering information in the suggested resources section.

- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only and should be used with objectives as indicated below.

  TM 1—Types of Resistors (Objective 14)
  TM 2—Resistor Color Code (Objective 17)
  TM 3—Left-Hand Rule for Conductors (Objective 21)
  TM 4—Left-Hand Rule for Coils(Objective 22)
  TM 5—Voltage Divider (Objective 27)
  TM 6—Unloaded Voltage Divider (Objective 28)
  TM 7—Loaded Voltage Divider (Objective 28)
  TM 8—Balanced Bridge (Objective 29)

- Select teacher components (written test, unit evaluation form) you want to distribute to your students. Copy and prepare these components for distribution.

- Prepare classroom. Put up posters and charts and display articles and other references related to the objectives of this unit.

Delivery and Application

Unit Introduction

- Discuss unit and specific objectives.

- Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.

- Discuss the assignment sheets and job sheets. Review with students the criteria for evaluation of each of these activities.

Suggested Activities

Teaching Suggestions

The skill areas appearing in bold-face type in the teaching suggestions refer to the academic and workplace skills identified in *What Work Requires of School: A SCANS Report for America 2000* and *Workplace Basics: The Skills Employers Want*. These have been adapted by MAVCC.

- Provide the students with examples of the various components discussed in the unit. Show both individual components and applications. Have the students identify applications in their cars, homes, workplaces, and elsewhere. Provide schematics with varying types of standard and non-standard symbols for these components. Use catalogs to discuss such parts, their values, environmental limitations, and other characteristics. **(Listening; reading; seeing things in the mind's eye; applying technology; selecting technological components; interpreting information; materials and resources)**

- Demonstrate the operation of the components covered in the information sheet. For example, blow fuses and pop circuit breakers. Demonstrate variable resistance in circuits with potentiometers and rheostats. Show how various types of switches, relays, and inductors work. Demonstrate sensors and environmentally sensitive devices and have the students brainstorm applications for such devices. **(Listening; science; applying technology; understanding system interrelationships; monitoring systems)**

- Discuss applications of voltage dividers and bridge circuits. Have the students brainstorm applications for such circuits. Have the students use the wheatstone bridges that they build in Job Sheet 7 to test resistors as part of Job Sheet 12. Discuss other types of bridge circuits including semiconductor applications (bolometer, Kelvin double, Varley-loop, voltage-sensitive, and allude to AC bridges). Give the students lists of such bridges and have them determine what the bridges are used for. **(Listening; seeing things in the mind's eye; applying technology; selecting tools and procedures; materials and facilities; science; troubleshooting; interpreting information)**

- Invite a reliability engineer or electrical engineer who specializes in reliability factors to discuss this specialty area in regard to resistors, other components, and assemblies. Discuss military requirements for reliability. Discuss how components are manufactured or "screened" for reliability, tolerances, and other characteristics. Review data books to determine available information on reliability and tolerances. **(Listening; applying technology; adapting to the organization's goals and values; materials and facilities; acquiring and evaluating information)**

Suggested Activities

- Provide students with assorted resistors to let them classify the resistors based on color coding, including resistors installed on circuit boards in which you ask the students to identify characteristics by resistor number. Provide the students with a memory device to help them remember the sequence of color code colors. For example, use "Black Bart's Red Onion Yogurt Gave Bart Very Gray Whiskers." **(Listening; reasoning; seeing things in the mind's eye; evaluating and acquiring information; processing information)**

- Construct DC circuits and use them to demonstrate the various calculations required in support of the assignment sheets, such as voltage drops, resistance in parallel circuits, and total voltage in series-parallel circuits. Then use the same circuits with installed defects to support Job Sheet 17 for troubleshooting DC circuits. **(Listening; adapting to the organization's values and traditional modes of operation; applying technology; maintenance and troubleshooting; problem solving; reasoning)**

Evaluation

- Discuss with students the use of the Unit Evaluation Form. Explain the rating scale that will be used for student evaluation.

- Copy written test and give to students as pretest. Record pretest score on the Unit Evaluation Form.

- Evaluate assignment sheets. See the evaluation criteria listed at the top of each assignment sheet and the component "Answers to Assignment Sheets."

- Evaluate job sheets. See the evaluation criteria listed at the top of each job sheet.

- Give and evaluate written test.

- Compile written-test, assignment-sheet, and job sheet scores on the Unit Evaluation Form. Include any additional assignments.

- Measure competency gains by comparing written pretest scores with posttest scores.

- Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas of improvement.

- Reteach and retest as required.

Suggested Activities

Instructions for Evaluating Student Performance

- When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

  Sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

  Option A

  4 — Skilled—Can perform job with no additional training.
  3 — Moderately skilled—Has performed job during training program; limited additional training may be required.
  2 — Limited skill—Has performed job during training program; additional training is required to develop skill.
  1 — Unskilled—Is familiar with process, but is unable to perform job.

  Option B

  Yes—Can perform job with no additional training.

  No—Is unable to perform job satisfactorily.

Suggested Resources

Resources Used in Developing This Unit

- *Basic Electronics*. Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1987.
- *Communications Electronics*. Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1988.
- Davidson, Homer L. *Electronic Troubleshooting and Repair Handbook*. New York: McGraw-Hill, 1995.

Suggested Activities

- Davidson, Homer L. *Troubleshooting and Repairing Compact Disc Players.* 2nd edition. New York, New York: TAB Books, 1994.
- *General Electronics Technician.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1987.
- *Graphic Symbols for Electrical and Electronics Diagrams.* New York: Institute of Electrical and Electronics Engineers, Inc., 1975.
- *Home Electronics.* Alexandria, Virginia: Time-Life Books, 1988.
- McMenamin, J. Michael. *Applied Electronic Devices and Analog ICs.* Albany, New York: Delmar Publishing, Inc., 1995.
- Newby, Bruce. *Electronic Signal Conditioning.* Oxford, England: Butterworth-Heinemann Ltd., 1994.
- Pallás-Areny, Ramón and John G. Webster. *Sensors and Signal Conditioning.* New York: John Wiley & Sons, Inc., 1991.
- Roehrig, Guido and Ulrich Schueller. *Upgrading and Maintaining Your PC.* Grand Rapids, Michigan: Abacus, 1991.
- Schuler, Charles A. *Electronics Principles and Applications.* 4th edition. New York: Glencoe Division, Macmillan/McGraw-Hill School Publishing Company, 1994.
- Simpson, Colin D. *Principles of DC/AC Circuits.* Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1996.
- Simpson, Colin D. *Principles of Electronics.* Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1996.
- Villanucci, Robert S., Alexander W. Avtgis, and William F. Megow. *Electronics Techniques: Shop Practices and Construction.* 5th Edition. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1996.

Supplemental Resources

Print Media

- Data books and resource sheets from a variety of electronics components and equipment manufacturers.

Suggested Activities

Non-print Media

- *Advanced Methods of DC Circuit Analysis.* Part of the *Understanding Semiconductors* series, this program emphasizes basic operational laws, such as Ohm's, Kirchhoff's, Thévenin's, and others. Available from: Texas Instruments Learning Center; Mail Station 54; P.O. Box 225012; Dallas, TX 75265.

Software

- *Resistor Codes.* An interactive program to help students learn the meaning of resistor color bands. Available from: MECC; 3490 Lexington Ave. North; St. Paul, MN 55126-8097.

DC and DC Circuits
Unit 4

Answers to Assignment Sheets

Assignment Sheet 1—Calculate Resistance Values from Color Codes

1. 22 Kohms
2. 82 ohms
3. 47 Kohms
4. 2200 ohms
5. 2420 ohms
6. 1980 ohms
7. 6200 ohms
8. 1.1 ohm
9. 4700 Kohms (or 4.7 Mohms)
10. 5.64 Mohms
11. 270 ohms
12. 820 Mohms
13. Reliability
14. 13 Kohms
15. 5.6 ohms
16. The one in item number 8 .
17. The one in item number 12.

Assignment Sheet 2—Determine Total Voltage in a Series Circuit

1. 50 V
2. 100 V
3. 40,000 V (or 40 Kvolts)
4. 1000 V
5. 340 V
6. 100 V
7. 250 V
8. 1000 V

Assignment Sheet 3—Determine Voltage Drops Across Resistances

1. R1
2. R3
3. 25 V
4. 45 V
5. 20 V

Assignment Sheet 4—Determine Total Resistance in a Series Circuit

1. 6 ohms
2. 5 ohms
3. 3 ohms
4. 15 ohms
5. 100 ohms

Answers to Assignment Sheets

Assignment Sheet 5—Determine Current in a Series Circuit

1. 2 A
2. 500 mA
3. 40 mA
4. 5 mA
5. 200 mA

Assignment Sheet 6—Compute Power Dissipated in a Resistive Series Circuit

1. 30 W
2. 20 W
3. 3 W
4. 40 W
5. 2 A

Assignment Sheet 7—Calculate Current and Voltage in Parallel Circuits

1. a. 50 V
   b. 5 A
   c. 50 V
   d. 5 A
   e. 10 A
2. a. 100 V
   b. 5 A
   c. 100 V
   d. 5 A
   e. 10 A
3. a. 20 V
   b. 20 V
   c. 20 V
   d. 4 A
   e. 4 A
   f. 2 A
   g. 10 A
4. a. 60 V
   b. 60 V
   c. 60 V
5. a. 3 A
   b. 6 A
   c. 2 A
   d. 11 A
6. a. 4 A
   b. 8 A
   c. 20 V
   d. 20 V
7. a. 6 mA
   b. 2 mA
   c. 100 V
   d. 100 V
   e. 100 V
   f. 100 V
8. 10 A

Answers to Assignment Sheets

Assignment Sheet 8—Calculate Resistance in Parallel Circuits

1. 10 ohms
2. 30 ohms
3. 20 ohms
4. 5 ohms
5. a. 20 ohms
   b. 30 ohms
   c. 12 ohms
   d. 12 ohms

Assignment Sheet 9—Calculate Power in Parallel Circuits

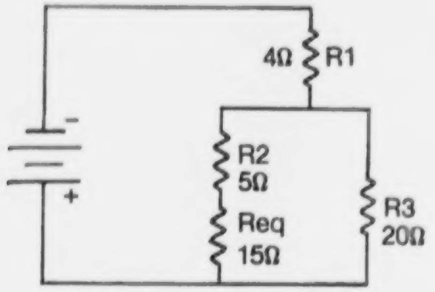
1. 400 W
2. 2500 W
3. 45 W
4. 600 W
5. 200 W

Assignment Sheet 10—Solve for Branch Voltages and Currents in Series-Parallel Circuits

1. a. 20 V
   b. 2 A
   c. 20 V
2. a. 5 V
   b. 5 V
   c. 0.5 A
   d. 5 V
3. a. 28.5 V
   b. 1.4 A
   c. 0.7 A

Assignment Sheet 11—Solve for Total Resistance in Series-Parallel Circuits

1. 15 ohms
2.



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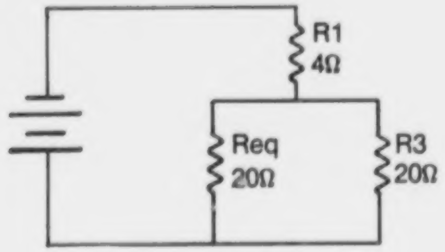

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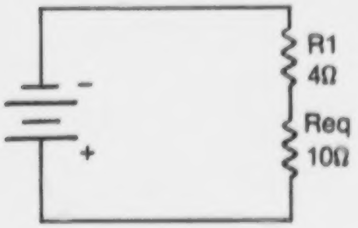
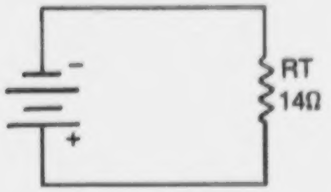


5.



Assignment Sheet 12—Solve for Total Current in Series-Parallel Circuits

1. 3 A
2. 6 A
3. 4 A
4. 10 A
5. 10 A

Assignment Sheet 13—Solve for Total Voltage in Series-Parallel Circuits

1. 50 V
2. 30 V
3. 40 V
4. 40 V
5. 15 V

Assignment Sheet 14—Solve for Total Power in Series-Parallel Circuits

1. 150 W
2. 100 W
3. 300 W
4. 41 W
5. 30 W

Answers to Assignment Sheets

Assignment Sheet 15—Analyze DC Circuits

1. Point Y
2. Point Z
3. R1 and R4
4. R2 and R3
5. a and d
6. Point C
7. Point A
8. No
9. R3, R4, R5
10. R1 and R6
11. All are correct
12. Point A
13. Point B
14. Point C
15. d
16. One (R1)
17. Yes
18. a, b, d
19. Point A
20. Point C
21. Yes
22. Yes
23. None
24. No
25. No
26. Yes
27. No
28. No
29. Yes
30. No
31. 12 A
32. Yes
33. b
34. b
35. -20 V
36. +20 V
37. +40 V
38. +60 V
39. -50 V
40. -30 V
41. +30 V
42. +70 V
43. +120 V
44. 30 ohms
45. 1 A
46. 10 V
47. 10 V
48. 10 V
49. -10 V

Answers to Assignment Sheets

50. +10 V
51. +20 V
52. C
53. No
54. 5 ohms
55. 25 ohms
56. 1.2 A
57. 12 V
58. 12 V
59. 6 V
60. a. Decrease
    b. Decrease
    c. Increase
    d. Increase
    e. Decrease

DC and DC Circuits
Unit 4

Answers to Written Test

1.	a.	14	e.	7	i.	2	m.	8
	b.	10	f.	9	j.	15	n.	3
	c.	1	g.	11	k.	4	o.	6
	d.	5	h.	12	l.	13		

2. Because electronic equipment deals with signals, direct current is used because changes in the current indicate changes in the signal.

3. a. DC source—Use of a circuit power source that produces direct current
   b. Rectification—Routing AC through a device that allows electrical flow in one direction only

4.	a.	9	d.	3	g.	8	j.	6
	b.	5	e.	2	h.	7	k.	10
	c.	11	f.	4	i.	1		
5.	a.	1	d.	6				
	b.	2	e.	5				
	c.	4	f.	3				
6.	a.	4	d.	6				
	b.	1	e.	3				
	c.	5	f.	2				
7.	a.	2	d.	4				
	b.	5	e.	1				
	c.	6	f.	3				
8.	a.	7	d.	3	g.	1	j.	9
	b.	5	e.	4	h.	2		
	c.	10	f.	8	i.	6		
9.	a.	3	d.	4	g.	10	j.	6
	b.	8	e.	1	h.	2	k.	9
	c.	5	f.	11	i.	7	l.	12

10. a. Bat handle
    b. Knife
    c. Rocker
    d. Pushbutton
    e. Thermostat
    f. Paddle handle
    g. Knob
    h. Key
    i. Lever

Answers to Written Test

11. a. Circuit breaker
b. Blade fuse
c. Fusible link
d. Cartridge fuse

12. a. 3
b. 2
c. 1

13. a. 2
b. 1
c. 3

14. a. Film element resistor
b. Carbon film resistor
c. Thermistor
d. Wire-wound variable resistor
e. Carbon composition resistor
f. Wire-wound rheostat
g. Wire-wound resistor
h. Carbon composition potentiometer
i. Wire-wound potentiometer

15. a. 3
b. 7
c. 5
d. 9
e. 1
f. 4
g. 2
h. 8
i. 6

16. a. 4
b. 2
c. 1
d. 3

17. a. First band—First significant number in resistance value
b. Second band—Second significant number in resistance value
c. Third band—Multiplier number for power of 10, which equates to the number of zeroes to add to the first and second significant numbers to get the resistance value
d. Fourth band—Shows tolerance as a percentage of the rated resistance
e. Fifth band—Reliability rating

18. a. 1
b. 3
c. 9
d. 8
e. 13
f. 6
g. 2
h. 11
i. 5
j. 12
k. 4
l. 10
m. 7

19. a. 3
b. 6
c. 2
d. 5
e. 1
f. 4

Answers to Written Test

20. a. 4 d. 2
b. 1 e. 3
c. 6 f. 5

21. With your left hand grasping the conductor with your thumb pointing in the direction of electron flow, the direction of the induced magnetic field is in the direction your fingers point.

22. With the coil isolated from power and your left hand fingers wrapped around the coil in the direction of electron flow, your thumb points to the north pole of the coil.

23. a. 2 d. 4 g. 5
b. 3 e. 1
c. 6 f. 7

24. a. 1 d. 4 g. 6
b. 3 e. 2
c. 7 f. 5

25. a. 11 e. 14 i. 2 m. 9
b. 3 f. 7 j. 1 n. 5
c. 4 g. 10 k. 13
d. 12 h. 8 l. 6

26. a. 9 e. 2 i. 6 m. 5
b. 13 f. 10 j. 3 n. 12
c. 1 g. 14 k. 8
d. 11 h. 7 l. 4

27. a. Voltage, current
b. Series
c. Voltage drops
d. Chassis

28. a. Loads
b. Parallel
c. 90
d. Bleeder

29. a. 1
b. 4
c. 2
d. 3

30. a. Wheatstone bridge
b. Balanced bridge
c. Unbalanced bridge
d. Simple bridge

DC and DC Circuits
Unit 4

Written Test

Name______________________ Date__________ Score__________

1. Match terms associated with DC and DC circuits to their correct definitions. Write the corresponding numbers on the blanks provided.

_______a. Amount of variance that is allowed from a standard value for a product or process to still be considered acceptable

_______b. Condition of an electrical circuit or portion of a circuit in which the temperature rises above the designed operating temperature

_______c. Coil that opposes AC while allowing free flow of DC that is wired in series with one of the electrodes of a gas discharge lamp

_______d. Use of colors to represent characteristics of components

_______e. Of an electronic component, having a single value

_______f. A current that is higher than the specified current for a circuit

_______g. Having or requiring a specific alignment of negative and positive leads or terminals

_______h. Expected performance life of a component or device under intended operational conditions

_______i. A level set as an operating point for an electrical or signal parameter such as voltage or resistance

_______j. Capable of changing in value or a characteristic that changes in value

_______k. A component or device that is connected across the terminals of a bridge circuit

_______l. Connection made to an intermediate point of a component, such as a coil or resistor

1. Ballast
2. Bias
3. Bleed current
4. Bridge
5. Color code
6. Electrolyte
7. Fixed
8. Latching
9. Overcurrent
10. Overheat
11. Polarized
12. Reliability
13. Tap
14. Tolerance
15. Variable

Written Test

______m. Referring to the characteristic of a component to lock into a position

______n. In a loaded voltage divider, that portion of the current that is routed through the voltage divider rather than the load

______o. Substance that ionizes in solution used in batteries to produce electricity through chemical action

2. State the reason for using direct current in electronic equipment.

____

____

____

3. Describe methods for providing direct current for electronic equipment.

a. DC Source—______________________________________

____

b. Rectification—____________________________________

____

4. Match common types of DC circuit components to their correct functions. Write the corresponding numbers on the blanks provided.

______a. Produce mechanical movement through the use of electromagnetism

______b. Protect circuits from overheating and overcurrent without reset capability

______c. Provide variable level of resistance based on changes in temperature

______d. Protect circuits from overheating or overcurrent with reset capability

______e. Serve as power source

______f. Produce inductance

______g. Provide a desired level of opposition to electrical flow in a circuit

1. Capacitors
2. Cells
3. Circuit breakers
4. Coils
5. Fuses
6. Lamps
7. Relays
8 Resistors
9. Solenoids

Written Test

______h. Provide switching capability in response to signals

______i. Collect excess electrons

______j. Provide illumination and serve as indicators

______k. Open and close circuits or redirect signals

10. Switches
11. Thermistors

5. Match ways of classifying batteries to their correct descriptions. Write the corresponding numbers on the blanks provided.

______a. Classification based on whether the cell or battery can be returned to a state of full voltage capacity or can only be used once until the charge is depleted

______b. Classification generally based on whether the internal chemical used to produce electrical flow is a solid or liquid

______c. Classification based on the battery chemical or chemical group

______d. Fully charged output capacity of the battery or cell

______e. Classification based on the metal or dissimilar metals used to supply electrons for electrical flow

______f. Standardized codes usually consisting of one or more letters that represent the size, shape, and voltage of a battery or cell

1. Capacity for recharging
2. Form of electrolyte
3. Packaging designations
4. Type of electrolyte
5. Type of electrode
6. Voltage capacity

6. Match lamps used in DC circuits to their correct descriptions. Write the corresponding numbers on the blanks provided.

______a. Lamp in which an internal conductor wire called a filament is heated so that it produces visible light

______b. A glow lamp that uses an iron core choke circuit wired in series with one electrode to create an electrical discharge

1. Ballast lamp
2. Fluorescent
3. Glow lamp
4. Incandescent

Written Test

______c. A lamp that is coded—such as by its color, location, or marking—so that it provides information by being illuminated or not illuminated

______d. A semiconductor device that gives off visible light when voltage is applied to its terminals

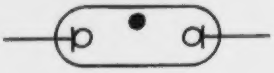
______e. Any of various types of lamps that use gas-filled tubes in which light is produced by the ionization of gas between the electrodes of the lamp

______f. Mercury-vapor glow lamp whose tube is lined with a phosphor that emits light when excited by the ultraviolet discharge created when an electrical current is sent through it

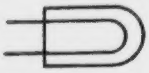
5. Indicator lamp
6. Light-emitting diode

7. Match lamps used in DC circuits to their correct symbols. Write the corresponding numbers on the blanks provided.

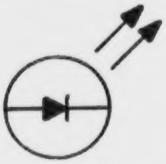
______a.



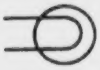
______b.



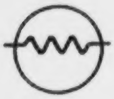
______c.



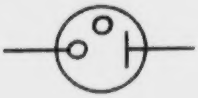
______d.



______e.



______f.



1. Ballast lamp
2. Fluorescent
3. Glow lamp
4. Incandescent
5. Indicator lamp
6. Light-emitting diode

Written Test

8. Match switches used in DC circuits to their correct descriptions. Write the corresponding numbers on the blanks provided.

______a. A switch with one or more poles that move together between one position and a second position

______b. Switch with two or more positions that is actuated by turning it in a circular motion

______c. Switch whose on and off positions are at the extremes of the movement of a lever

______d. Switch that generally consists of two or more electrodes encased in a hollow, sealed body which contains a small quantity of mercury that is free to move so that changes in switch position make or break contact between the conductive mercury and a set of electrodes

______e. A switch that is opened or closed by depressing it

______f. Switch with two or more positions that is actuated by moving it back and forth along a line

______g. A switch with two or more poles that move together among three points so that one pole or set of poles is closed in one position, the other pole or set of poles is closed in a second position, and a third position exists where neither pole or set of poles is closed

______h. Term applied to two types of switches, one of which is operated by inserting and rotating a key and the other of which provides a momentary contact that automatically releases, such as a computer keyboard key or telegraph key

______i. Switch wired in series with the power circuit of a piece of equipment so that certain conditions, such as opening a cabinet door or exceeding a safe operating speed, causes the switch to open and power to be removed

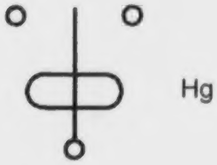
1. Double-throw
2. Key-type
3. Mercury switch
4. Pushbutton
5. Rotary
6. Safety interlock
7. Single-throw
8. Slide
9. Thermostat
10. Toggle

Written Test

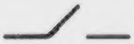
______j. Switch that opens or closes as a result of changes in temperature, often through the use of a bi-metal conductor that bends to make or break contact as it expands and contracts in response to temperature changes

9. Match switches used in DC circuits to their correct symbols. Write the corresponding numbers on the blanks provided.

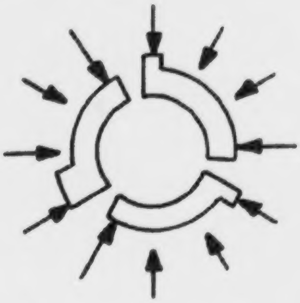
______a.



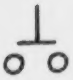
______b.



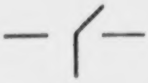
______c.



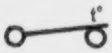
______d.



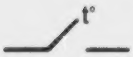
______e.



______f.



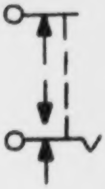
______g.



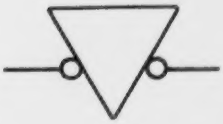
1. Double-throw
2. Key-type
3. Mercury
4. Pushbutton
5. Rotary
6. Safety interlock, circuit closing
7. Safety interlock, circuit opening
8. Single-throw
9. Slide
10. Thermostat, open on falling temperature
11. Thermostat, open on rising temperature
12. Toggle (locking type)

Written Test

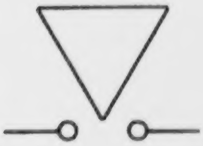
_____h.



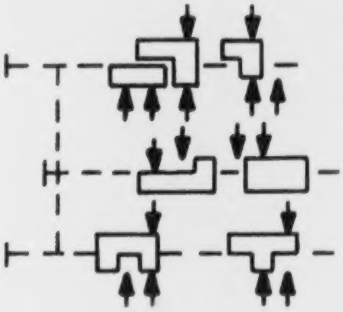
_____i.



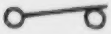
_____j.



_____k.



_____l.

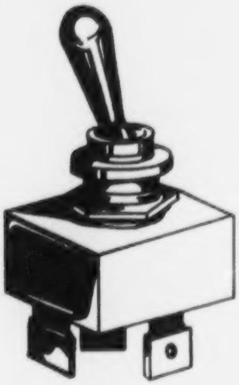


421

Written Test

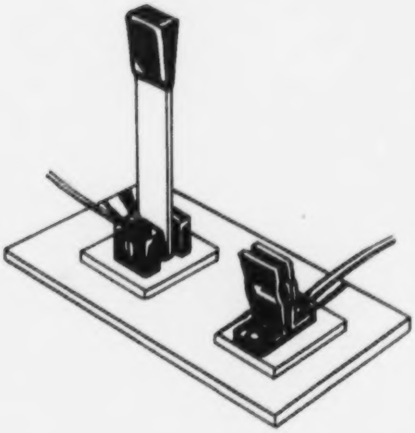
10. Identify methods of manually actuating switches.

a.



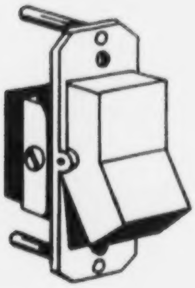
____

b.



____

c.

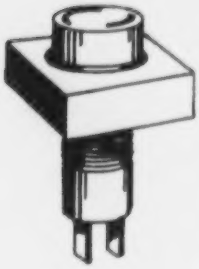


____

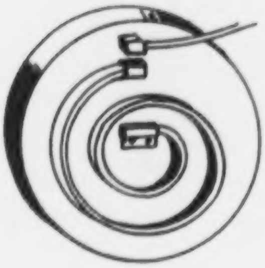
422

Written Test

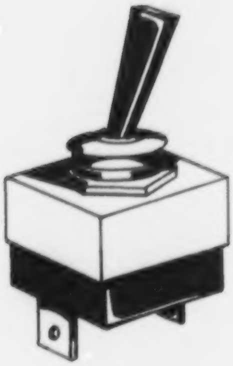
d.



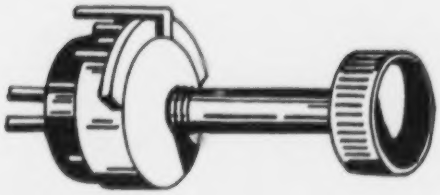
e.



f.

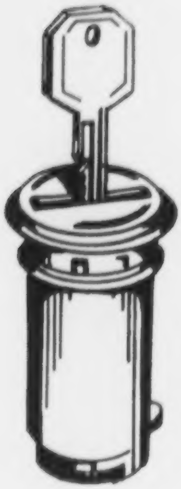


g.



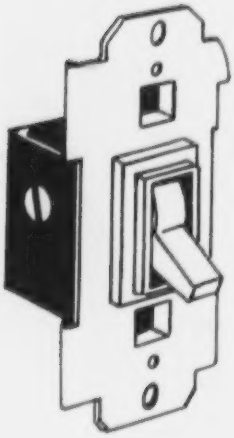
423

h.



____

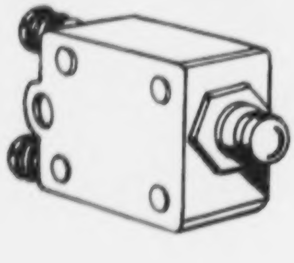
i.



____

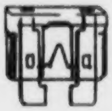
11. Identify circuit protection devices used in DC circuits.

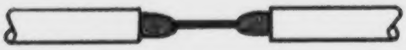
a.

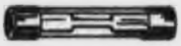


____

424

b.  ____________________

c.  ____________________

d.  ____________________

12. Match circuit protection devices to their correct descriptions. Write the corresponding numbers on the blanks provided.

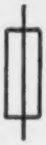
_____a. Segment of conductor spliced into a second conductor having a higher gauge than the second conductor so that it will melt more quickly than the larger conductor in the event of a high current condition

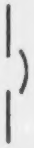
_____b. Unresettable device with an internal conductor that is designed to melt in the event of a high current condition

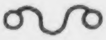
_____c. Resettable device with moveable contacts that separate in the event of a high corrent condition

1. Circuit breaker
2. Fuse
3. Fusible link

13. Match circuit protection devices used in DC circuits to their correct symbols. Write the corresponding numbers on the blanks provided.

_____a. 

_____b. 

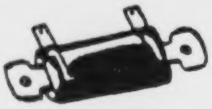
_____c. 

1. Circuit breaker
2. Fuse
3. Fusible link

Written Test

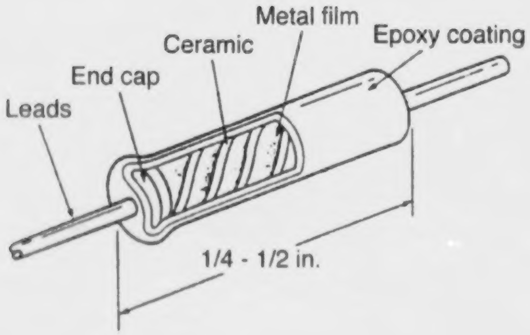
14. Identify types of resistors used in DC circuits.

a.



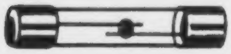
____

b.


Metal film
Epoxy coating
Ceramic
End cap
Leads
1/4 - 1/2 in.

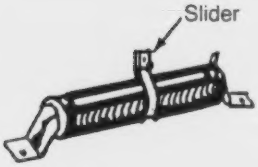
____

c.



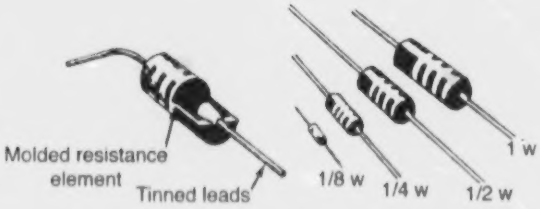
____

d.



____

e.

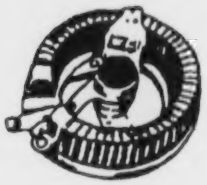

Molded resistance element
Tinned leads
1/8 w
1/4 w
1/2 w
1 w

____

426

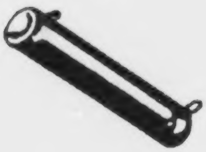
Written Test

f.



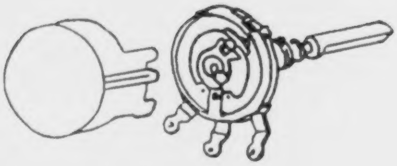
____

g.



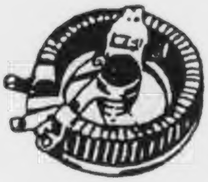
____

h.



____

i.



____

15. Match resistors used in DC circuits to their correct descriptions. Write the corresponding numbers on the blanks provided.

______a.	Component consisting of conducting leads extending from a glass or ceramic rod that has been coated with thin layers of a resistive material and enclosed in a protective outer layer	1.	Carbon composition potentiometer
		2.	Carbon composition resistor
______b.	Component consisting of a ceramic tube wrapped in a coil of nickel-chromium alloy wire and covered with a protective coating	3.	Carbon film resistor
		4.	Film element resistor

Written Test

_______c. A carbon-composition or film resistor that is constructed so that variations in temperature cause the overall resistance of the component to change

_______d. Component consisting of a ceramic tube wrapped in a coil of nickel-chromium alloy wire with one terminal attached to a moveable slide that can be positioned along the coil to change the overall resistance of the component

_______e. A three-terminal component constructed of circular carbon composition ribbons or wires with an arm attached to a moveable shaft so that the resistance varies as the shaft is turned

_______f. Component that opposes electrical flow through the use of a resistive substrate coated with a thin layer of resistive material such as tin oxide

_______g. Generally tube-shaped component consisting of a conductor enclosed in a mixture of carbon granules and insulating material in a binding agent and coated with a non-conductive substance

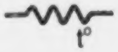
_______h. Two-terminal component consisting of a ceramic ring wrapped in nickel-chromium alloy wire with one terminal attached to a rotating shaft which moves the terminal connection around the ring to vary resistance

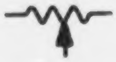
_______i. Three-terminal component consisting of a ceramic ring wrapped in nickel-chromium alloy wire with one terminal attached to a rotating shaft which moves the terminal connection around the ring to vary resistance

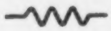
5. Thermistor
6. Wire-wound potentiometer
7. Wire-wound resistor
8. Wire-wound rheostat
9. Wire-wound variable resistor

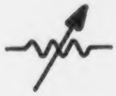
Written Test

16 Match resistors used in DC circuits to their correct descriptions. Write the corresponding numbers on the blanks provided.

______a. 

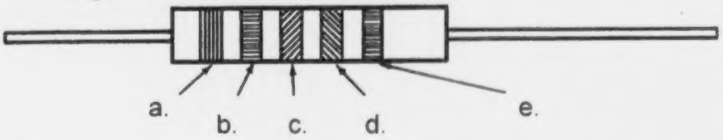
______b. 

______c. 

______d. 

1. Fixed
2. Potentiometer
3. Rheostat
4. Thermistor

17. Label the meanings of color bands of a resistor.



a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

18. Match colors used on resistors to their correct meanings. Write the corresponding numbers on the blanks provided.

______a. Represents the number 0

______b. Represents the number 1

______c. Represents the number 2 and the reliability rating 0.1

______d. Represents the number 3 and the reliability rating 0.01

______e. Represents the number 4 and the reliability rating 0.001

1. Black
2. Blue
3. Brown
4. Gold
5. Gray
6. Green
7. No color

Written Test

_______f. Represents the number 5

_______g. Represents the number 6

_______h. Represents the number 7

_______i. Represents the number 8

_______j. Represents the number 9

_______k. Represents the multiplier 0.1 and a 5-percent tolerance

_______l. Represents the multiplier 0.01 and a 10-percent tolerance

_______m. Represents a 20-percent tolerance and indicates that reliability was not tested

8. Orange
9. Red
10. Silver
11. Violet
12. White
13. Yellow

19. Match inductors used in DC circuits to their correct descriptions. Write the corresponding numbers on the blanks provided.

_______a. An inductor with a metal bar or ring (generally iron) within the winding to increase the induction strength

_______b. An inductor that has a connection at an intermediate point of its winding

_______c. Any of various component configurations that include one or more conductors tightly wrapped around a body

_______d. A general term for a coil and often applied specifically to one that has a magnetic core that is used as a mechanical actuator due to its movement in response to electromagnetic induction

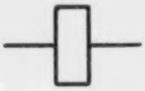
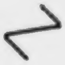
_______e. An inductor whose strength can be varied

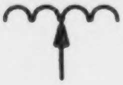
_______f. A switch that uses an electromagnetic actuator that responds to current applied to the winding or to increases in the current strength

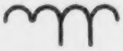
1. Adjustable
2. Coil
3. Magnetic core
4. Relay coil
5. Solenoid
6. Tapped

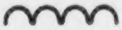
Written Test

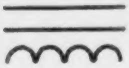
20. Match inductors used in DC circuits to their correct symbols. Write the corresponding numbers on the blanks provided.

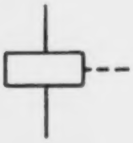
_____a.  or 

_____b. 

_____c. 

_____d. 

_____e. 

_____f. 

1. Adjustable
2. Coil
3. Magnetic core
4. Relay coil
5. Solenoid
6. Tapped

21. Explain the left-hand rule for conductors.

____

____

____

22. Explain the left-hand rule for coils.

____

____

____

23. Match sensor devices used in DC circuits to their correct descriptions. Write the corresponding numbers on the blanks provided.

_____a. Respond to changes in the amount of momentum of an object to which it is attached

1. Flow sensors
2. Inertia sensors

Written Test

_____b. Respond to the presence of specific substances in their immediate environment

_____c. Respond to changes in pressure when applied to the surface of a sensor

_____d. Respond to changes in the level of a surrounding substance

_____e. Respond to the rate of flow of a fluid

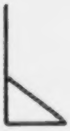
_____f. Respond to changes in temperature

_____g. Respond to light levels

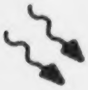
3. Ion sensors
4. Level sensors
5. Photo-sensitive devices
6. Pressure-sensitive devices
7. Thermal sensors

24. Match sensor devices used in DC circuits to their correct symbols. Write the corresponding numbers on the blanks provided.

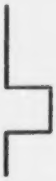
_____a.



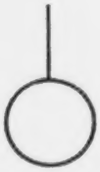
_____b.



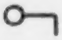
_____c.



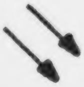
_____d.



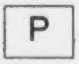
_____e.



_____f.



_____g.



1. Flow sensors
2. Inertia sensors
3. Ion sensors
4. Level sensors
5. Photo-sensitive devices
6. Pressure-sensitive devices
7. Thermal sensors

Written Test

25. Match relays used in DC circuits to their correct descriptions. Write the corresponding numbers on the blanks provided.

______a. Relay with no specific requirements for actuation, such as polarity or vast level differences in power for on and off

______b. Relay that is actuated by changes in either of two parameters, such as polarity and voltage

______c. Relay that operates only in response to a specific polarity

______d. A high-resistance relay

______e. Relay that is slow to break a circuit

______f. Relay that locks into whichever position (on or off) for which it is energized

______g. Relay with relatively small difference between its on and off power requirements

______h. Relay which provides a specific magnetic polarity in response to induction

______i. Relay actuated by a difference between two currents or voltages

______j. Relay whose action is delayed by the movement of a piston

______k. Relay that is slow to make a circuit

______l. Relay that tends to break a circuit quickly

______m. Relay with a permanent magnet in its coil that locks the relay into an energized position

______n. Relay that tends to make a circuit quickly

1. Dashpot
2. Differential
3. Double-biased
4. Electrically polarized
5. Fast-operate
6. Fast-release
7. Latching
8. Magnetically polarized
9. Magnetic latching
10. Marginal
11. No bias
12. Nonreactive
13. Slow-operate
14. Slow-release

Written Test

26. Match relays used in DC circuits to their correct symbols. Write the corresponding numbers on the blanks provided.

_______a. $\boxed{\text{ML}}$

_______b. $\boxed{\text{X}}$ or SO

_______c. $\boxed{\text{DP}}$

_______d. $\boxed{\text{NB}}$

_______e. $\boxed{\text{D}}$

_______f. $\boxed{\text{MG}}$

_______g. $\boxed{|||||||}$ or SR

_______h. $\boxed{\text{L}}$

_______i. $\boxed{\text{FR}}$

_______j. $\boxed{\text{DB}}$

_______k. $\boxed{+}$ or P

1. Dashpot
2. Differential
3. Double-biased
4. Electrically polarized
5. Fast-operate
6. Fast-release
7. Latching
8. Magnetically polarized
9. Magnetic latching
10. Marginal
11. No bias
12. Nonreactive
13. Slow-operate
14. Slow-release

______l. EP

______m. FO

______n. NR

27. Complete statements regarding the characteristics of voltage dividers.

    a. A voltage divider provides different __________ and __________ values for different loads from a single power source.

    b. A voltage divider consists of two or more resistors connected in __________ across the power source.

    c. The voltage is divided through successive __________ __________ through the resistors.

    d. If a __________ ground is used, the supplied voltage can be either negative or positive.

28. Complete statements regarding the operation of loaded and unloaded voltage dividers.

    a. Unloaded voltage dividers do not have __________ attached.

    b. Loaded voltage dividers have a load attached in __________.

    c. The divider generally is constructed to allow __________ percent of the total current to go through the load.

    d. The current that does not flow through the load is called the __________ current and flows through the series divider network.

29. Match types of bridge circuits to their correct descriptions. Write the corresponding numbers on the blanks provided.

______a. Bridge design with proportional resistance in each branch so that the voltage output across the terminals is 0

______b. Bridge design that includes a calibrated variable resistor in one branch so that a resistor of unknown value can be tested in the same branch by creating a balanced bridge

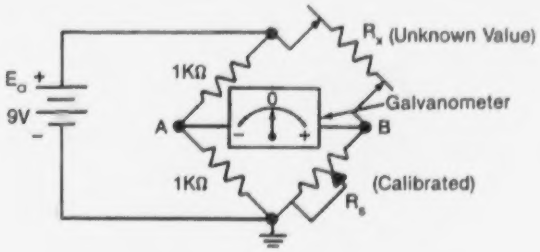
1. Balanced bridge
2. Simple bridge
3. Unbalanced bridge
4. Wheatstone bridge

_______c. A series-parallel circuit which has two input terminals and two output terminals

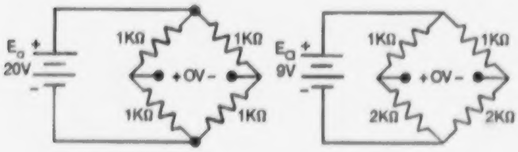
_______d. Bridge design in which a potential difference exists across the output terminals

30. Identify types of bridge circuits by their schematics.

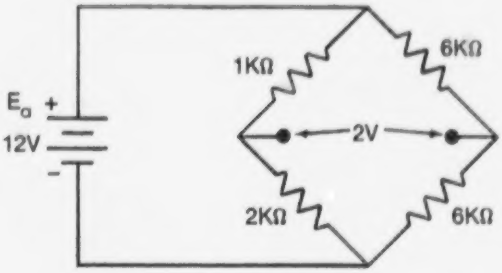
a.


E_a +
9V
-
1KΩ
1KΩ
A
B
0
- +
R_x (Unknown Value)
Galvanometer
(Calibrated)
R_s

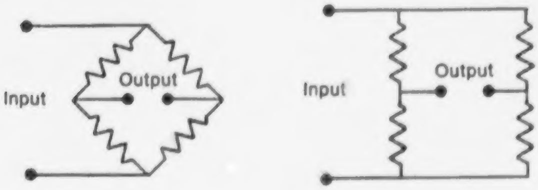
b.


E_a +
20V
-
1KΩ
1KΩ
1KΩ
1KΩ
+0V-
E_a +
9V
-
1KΩ
1KΩ
2KΩ
2KΩ
+0V-

c.


E_a +
12V
-
1KΩ
6KΩ
2V
2KΩ
6KΩ

d.


Input
Output
Input
Output

*Permission to duplicate this test is granted.

DC and DC Circuits
Unit 4

Unit Evaluation Form

Student Name ______________________________ Unit Rating ______________

Assignment Sheet Ratings

Assignment Sheet 1—Calculate Resistance Values from Color Codes Rating _____

Comments: ____

____

Assignment Sheet 2—Determine Total Voltage in a Series Circuit Rating _____

Comments: ____

____

Assignment Sheet 3—Determine Voltage Drops Across Resistances Rating _____

Comments: ____

____

Assignment Sheet 4—Determine Total Resistance in a Series Circuit Rating _____

Comments: ____

____

Assignment Sheet 5—Determine Current in a Series Circuit Rating _____

Comments: ____

____

Assignment Sheet 6—Compute Power Dissipated in a Resistive Series Circuit Rating _____

Comments: ____

____

Unit Evaluation Form

Assignment Sheet 7—Calculate Current and Voltage in Parallel Circuits Rating _____

Comments: ____

____

Assignment Sheet 8—Calculate Resistance in Parallel Circuits Rating _____

Comments: ____

____

Assignment Sheet 9—Calculate Power in Parallel Circuits Rating _____

Comments: ____

____

Assignment Sheet 10—Solve for Branch Voltages and Current in Series-Parallel Rating _____

Comments: ____

____

Assignment Sheet 11—Solve for Total Current in a Series-Parallel Circuit Rating _____

Comments: ____

____

Assignment Sheet 12—Solve for Total Power in a Series-Parallel Circuit Rating _____

Comments: ____

____

Assignment Sheet 13— Solve for Total Voltage in a Series-Parallel Circuit Rating _____

Comments: ____

____

Unit Evaluation Form

Assignment Sheet 14—Solve for Total Power in a Series-Parallel Circuit Rating _____

Comments: ____

____

Assignment Sheet 15—Analyze DC Circuits Rating _____

Comments: ____

____

Job Sheet Ratings

Job Sheet 1—Measure and Compare Current in a Circuit at Two Different Voltage Levels Rating _____

Comments: ____

____

Job Sheet 2—Wire a Functional Relay Circuit Rating _____

Comments: ____

____

Job Sheet 3—Measure the Voltage Drop in a DC Circuit Rating _____

Comments: ____

____

Job Sheet 4—Construct a Voltage Divider and Analyze Its Function Rating _____

Comments: ____

____

Job Sheet 5—Measure Voltages in a Balanced Bridge Circuit Rating _____

Comments: ____

____

Unit Evaluation Form

Job Sheet 6—Measure Voltages in an Unbalanced Bridge Circuit Rating _____

Comments: ____

____

Job Sheet 7—Construct and Operate a Wheatstone Bridge Rating _____

Comments: ____

____

Job Sheet 8—Determine the Maximum Power Transfer Point on a Resistor Circuit Rating _____

Comments: ____

____

Job Sheet 9—Test and Replace Cells Rating _____

Comments: ____

____

Job Sheet 10—Test and Replace Lamps Rating _____

Comments: ____

____

Job Sheet 11—Test and Replace Switches Rating _____

Comments: ____

____

Job Sheet 12—Test and Replace Resistors Circuits Rating _____

Comments: ____

____

Unit Evaluation Form

Job Sheet 13—Test and Replace Fuses and Circuit Breakers Rating _____

Comments: ______________________________

Job Sheet 14—Test and Replace Capacitors Rating _____

Comments: ______________________________

Job Sheet 15—Test and Replace Cells Rating _____

Comments: ______________________________

Job Sheet 16—Test and Replace Sensor Devices Rating _____

Comments: ______________________________

Job Sheet 17—Test and Replace Relays Rating _____

Comments: ______________________________

Job Sheet 18—Test and Replace Solenoids Rating _____

Comments: ______________________________

Job Sheet 19—Troubleshoot DC Circuits Rating _____

Comments: ______________________________

Unit Evaluation Form

Written-Test Scores

Pretest _______ Posttest _______ Other _______

Other ____

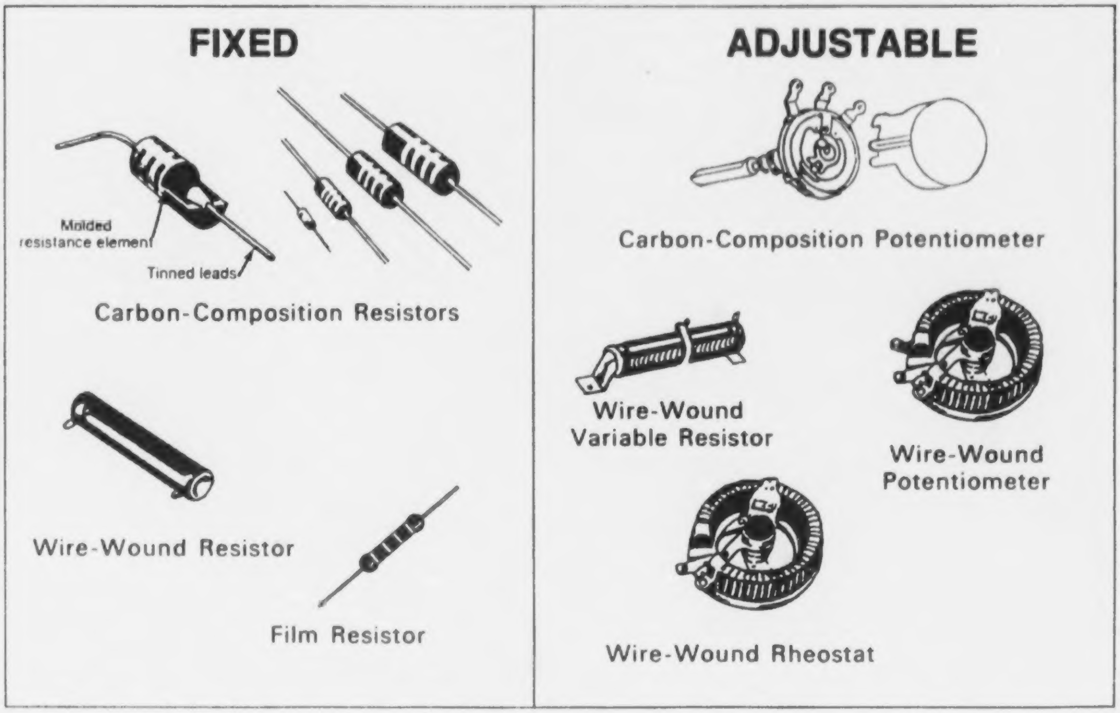
____

Teacher Signature ______________________________ Date ______________

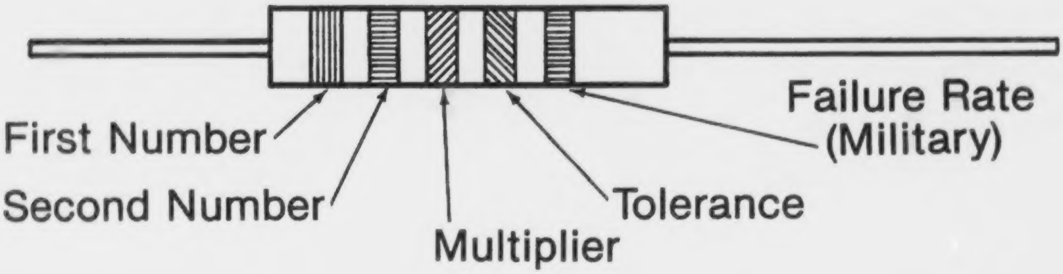
Student Signature ______________________________ Date ______________

*Permission to duplicate this form is granted.

Types of Resistors

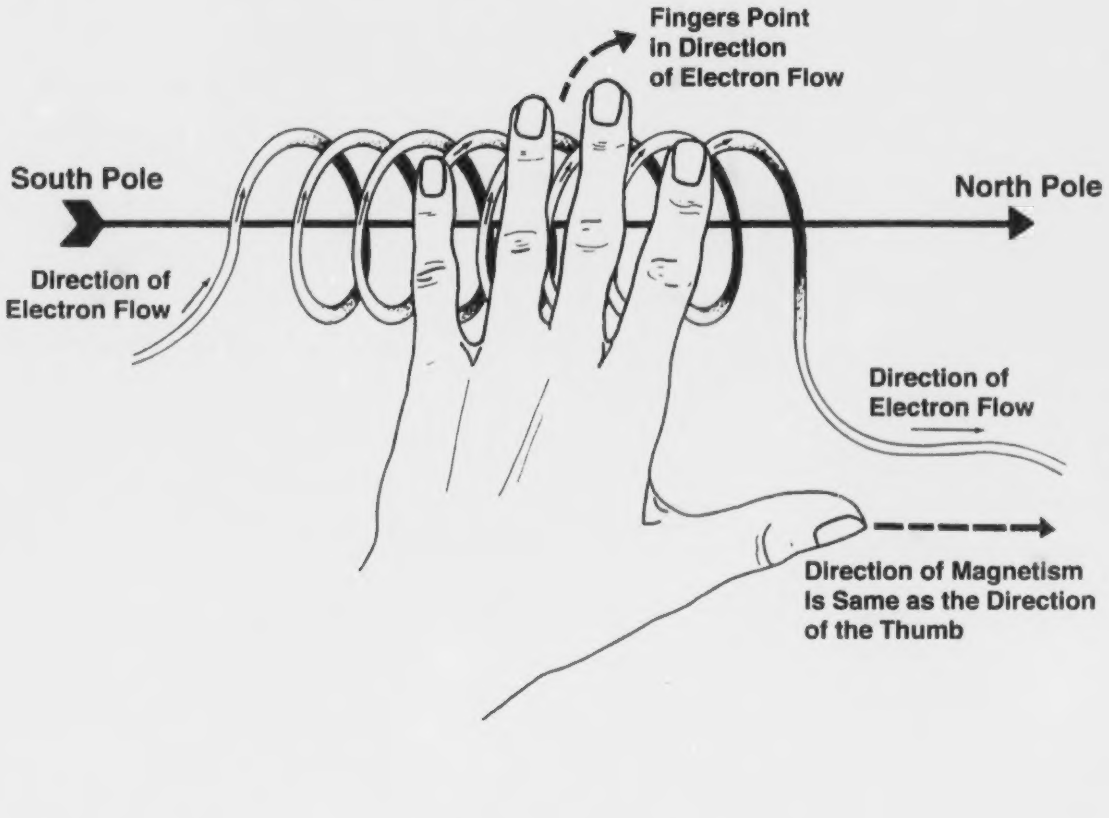

FIXED
Molded resistance element
Tinned leads
Carbon-Composition Resistors
Wire-Wound Resistor
Film Resistor
ADJUSTABLE
Carbon-Composition Potentiometer
Wire-Wound Variable Resistor
Wire-Wound Potentiometer
Wire-Wound Rheostat

Resistor Color Code

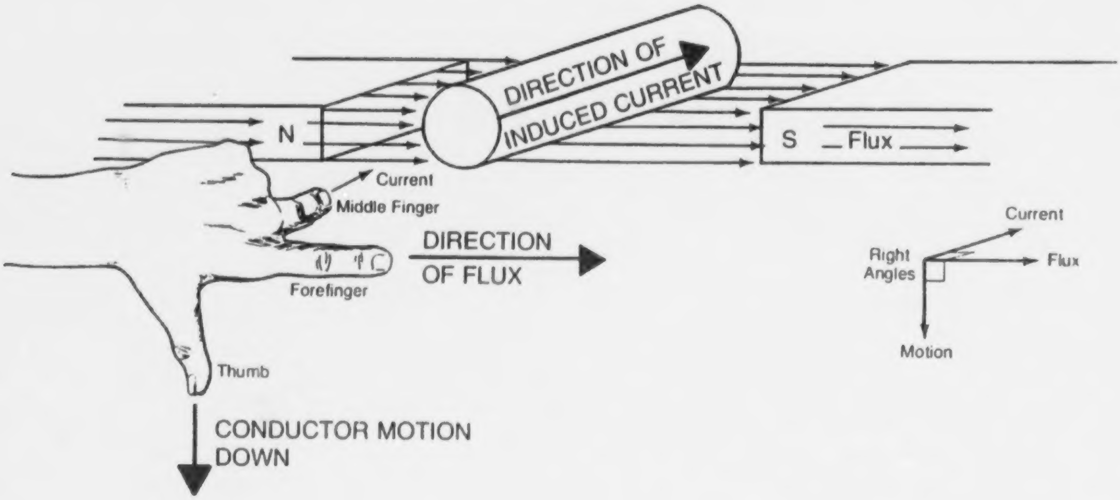

First Number
Second Number
Multiplier
Tolerance
Failure Rate (Military)

Color	First Number	Second Number	Multiplier	Tolerance	Failure Rate per 1000 hrs.
Black	0	0	1	± 20%	L 5%
Brown	1	1	10	± 1 %	M 1%
Red	2	2	100	± 2%	P 0.1%
Orange	3	3	1000	----	R 0.01%
Yellow	4	4	10000	----	S 0.001%
Green	5	5	100000	----	T 0.0001%
Blue	6	6	1000000	----	
Violet	7	7	10000000	----	
Gray	8	8		----	
White	9	9		----	
Gold	----	----	0.1	± 5%	
Silver	----	----	0.01	± 10%	
No Color	----	----	----	± 20%	

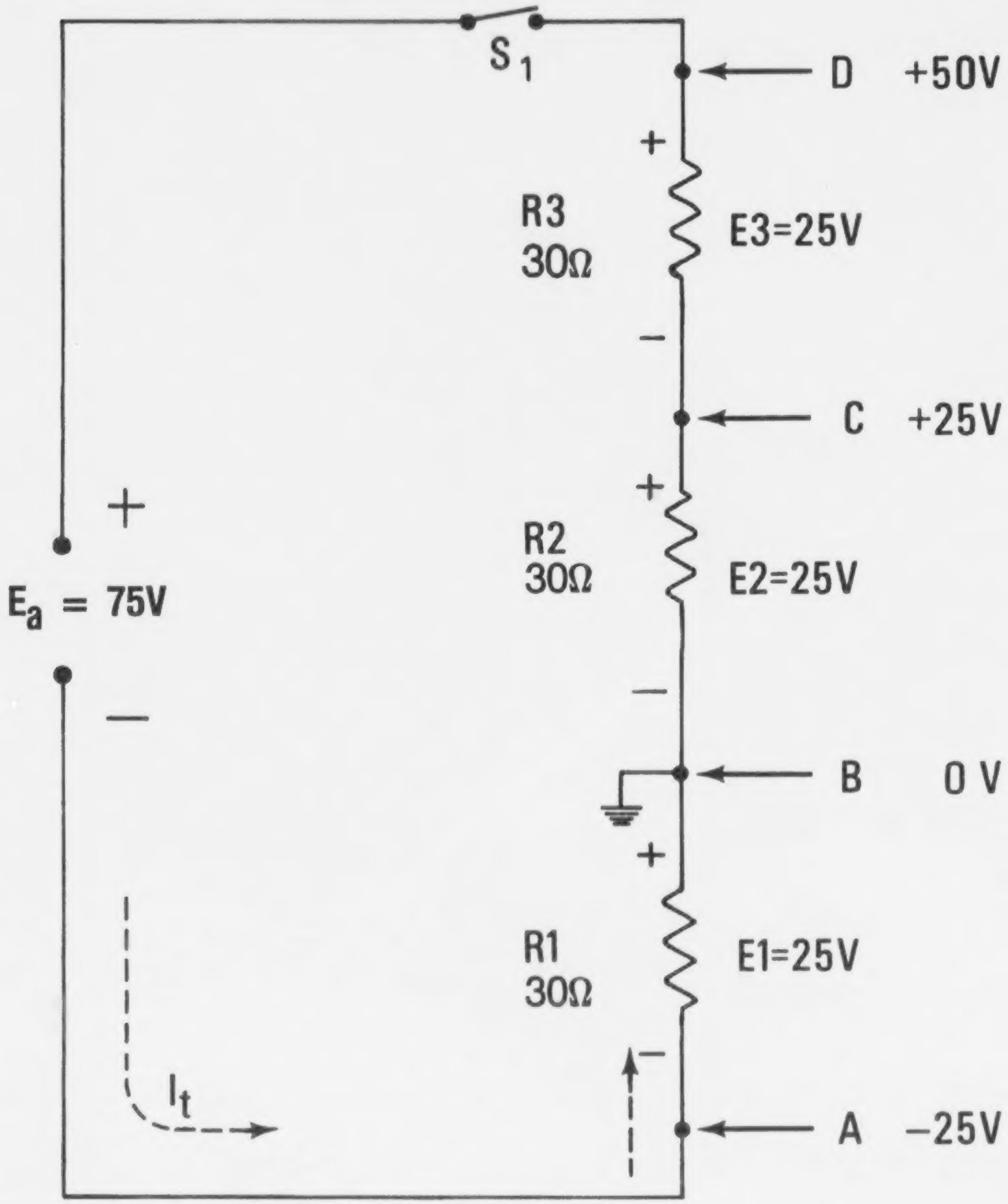
Left-Hand Rule for Conductors


Fingers Point in Direction of Electron Flow
South Pole
North Pole
Direction of Electron Flow
Direction of Electron Flow
Direction of Magnetism Is Same as the Direction of the Thumb

Left-Hand Rule for Coils


DIRECTION OF
INDUCED CURRENT
N
S
Flux
Current
Middle Finger
DIRECTION
OF FLUX
Forefinger
Thumb
CONDUCTOR MOTION
DOWN
Current
Right
Angles
Flux
Motion

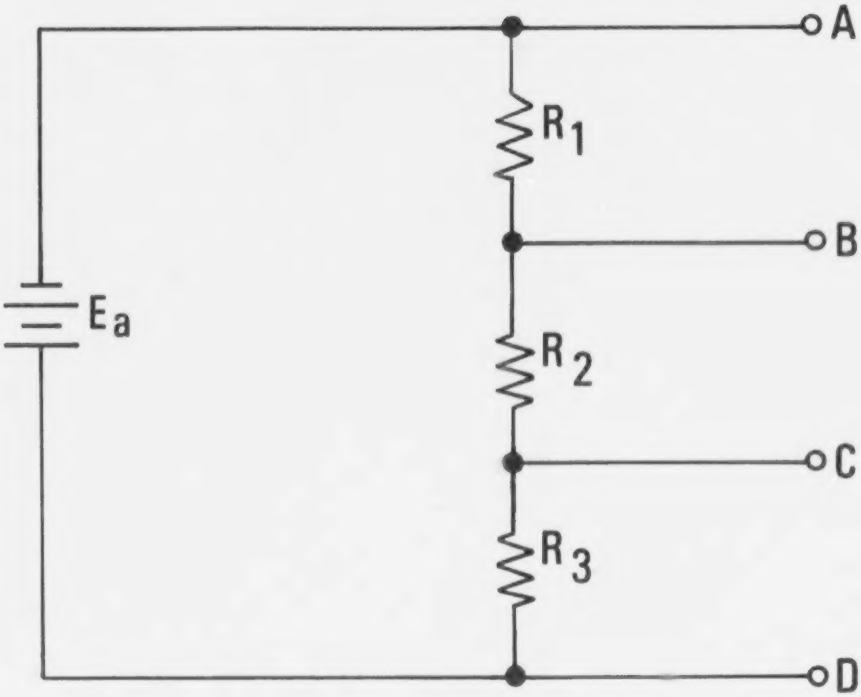
Voltage Divider


S1
D +50V
+
R3
30Ω
E3=25V
−
C +25V
+
R2
30Ω
E2=25V
−
B 0 V
+
R1
30Ω
E1=25V
−
A −25V
+
E_a = 75V
−
I_t

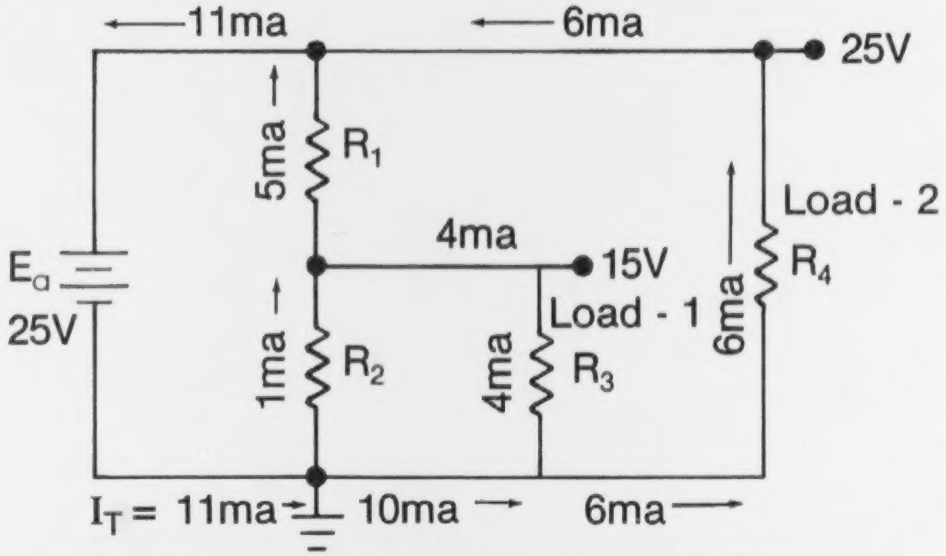
447

TM 5

Unloaded Voltage Divider


A
B
C
D
R_1
R_2
R_3
E_a

Loaded Voltage Divider



11ma
6ma
25V
5ma
R1
4ma
15V
Load - 2
R4
Ea
25V
Load - 1
6ma
1ma
R2
4ma
R3
IT = 11ma
10ma
6ma

Resistances may be calculated with Ohm's Law

$$R_1 = \frac{E_{R1}}{I_{R1}} = \frac{10V}{.005A} = 2000\Omega\ (2K\Omega)$$

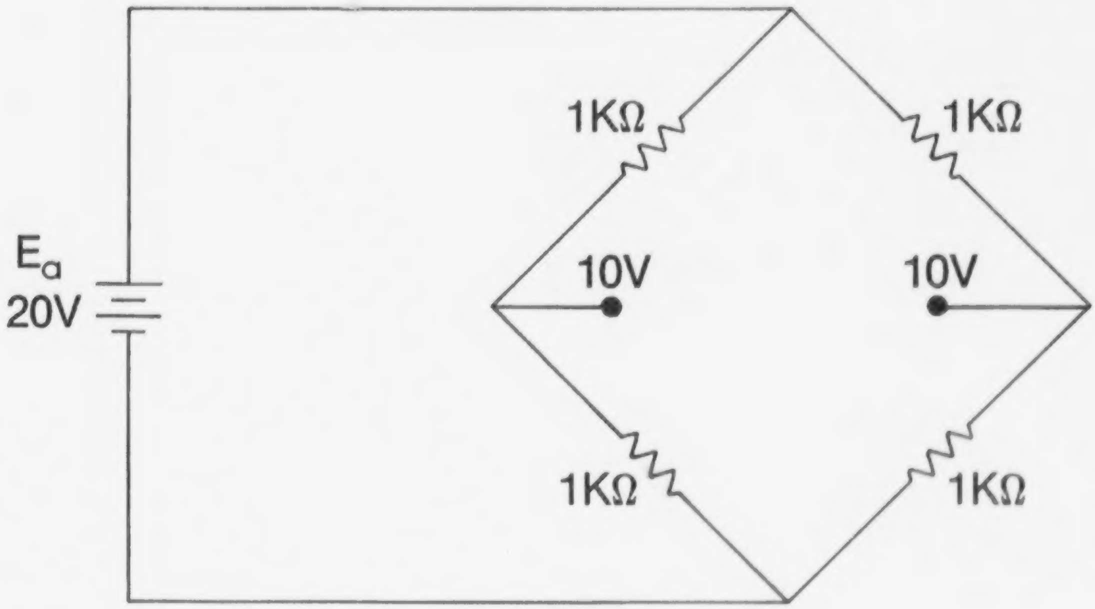
$$R_2 = \frac{E_{R2}}{I_{R2}} = \frac{15V}{.001A} = 15000\Omega\ (15K\Omega)$$

$$R_3 = \frac{E_{R3}}{I_{R3}} = \frac{15V}{.004} = 3750\Omega\ (3.75K\Omega)$$

$$R_4 = \frac{E_{R4}}{I_{R4}} = \frac{25V}{.006A} = 4164\Omega\ (4.16K\Omega)$$

TM 7

Balanced Bridge


1KΩ
1KΩ
E_a
20V
10V
10V
1KΩ
1KΩ

AC and AC Circuits
Unit 5

Suggested Activities

Instructional Plan

Preparation

- Review unit and plan presentation. Study the specific objectives to determine the order in which you will present the objectives.

  Review the unit introduction and teaching suggestions included in the delivery and application section below, and plan classroom activities. Also note the suggestions for media and supplemental materials.

  Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.

- Obtain films, videotapes, and other media to supplement instruction of this unit. See ordering information in the suggested resources section.

- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only and should be used with objectives as indicated below.

  TM 1—Sine Wave Relationships (Objective 4)
  TM 2—Comparison of Sinusoidal and Phasor (Vector) Diagrams (Objective 5)
  TM 3—Trigonometric Functions (Objective 5)
  TM 4—Coils of Various Inductances (Objective 8)
  TM 5—Induction (Objective 8)
  TM 6—Self-Induction in a Coil (Objective 9)
  TM 7—Current and Voltage in an RL Circuit (Objective 10)
  TM 8—Simple AC Generator (Objective 12)
  TM 9—Types of Three-Phase Circuits (Objective 16)
  TM 10—Current Rise and Fall in an Inductor (Objective 18)
  TM 11—RL Circuit and Current Rise (Objective 24)
  TM 12—Power in RL Circuits (Objective 24)
  TM 13—Capacitor Construction (Objective 27)
  TM 14—Electric Field Effect on Dielectrics (Objective 27)
  TM 15—Plate Area (Objective 28)
  TM 16—Plate Distance (Objective 28)
  TM 17—Effect of the Dielectric (Objective 28)
  TM 18—Dielectric Strength of Common Insulators (Objective 28)
  TM 19—Current and Voltage Relationships in RC Circuits (Objective 34)
  TM 20—Voltage in RC Circuits (Objective 34)
  TM 21—Power in RC Circuits (Objective 35)

Suggested Activities

TM 22—Impedance in RC Circuits (Objective 36)
TM 23—Voltage Relationship in a Series RCL Circuit (Objective 42)
TM 24—Impedance Relationship in a Series RCL Circuit (Objective 42)
TM 25—Resonance Relationship in a Series RCL Circuit (Objective 43)
TM 26—Typical Resonant Curves (Objective 43)
TM 27—Current Relationship in a Parallel RCL Circuit (Objective 44)
TM 28—Resonance Relationship in a Parallel RCL Circuit (Objective 45)
TM 29—Tuned Parallel Circuit Curves (Objective 45)
TM 30—Impedance Matching (Objective 53)

- Select teacher components (written test, unit evaluation form) you want to distribute to your students. Copy and prepare these components for distribution.
- Prepare classroom. Put up posters and charts and display articles and other references related to the objectives of this unit.

Delivery and Application

Unit Introduction

- Discuss unit and specific objectives.
- Discuss information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets and job sheets. Review with students the criteria for evaluation of each of these activities.

Teaching Suggestions

The skill areas appearing in bold-face type in the teaching suggestions refer to the academic and workplace skills identified in *What Work Requires of School: A SCANS Report for America 2000* and *Workplace Basics: The Skills Employers Want*. These have been adapted by MAVCC.

- Provide the students with examples of capacitors, inductors, and the various types of circuits discussed in this unit. Show both individual components and applications. Have the students identify applications in their cars, homes, workplaces, and elsewhere. Provide schematics with varying types of standard and non-standard symbols for these components. Use catalogs to discuss such parts, their values, environmental limitations, and other characteristics. **(Listening; reading; seeing things in the mind's eye; applying technology; selecting technological components; interpreting information; materials and resources)**

- Discuss the role of AC power in electronics equipment. Display waveforms and phase relationships. Show both sinusoidal and nonsinusoidal waveforms. Make sure that the students understand wave relationships and constants, such as effective current and voltage. Demonstrate frequency changes and bandwidth applications. Have the students operate oscilloscopes with varying inputs to monitor waveform changes with differences in frequencies, voltages, and currents. **(Listening; science; applying technology; understanding system interrelationships; monitoring systems)**

- Discuss mathematical relationships in AC signals and ensure that your students have enough understanding of trigonometry and vectors to comprehend the concepts and solve the related problems. Use classroom demonstrations and require students to solve problems with class participation so that the students realize the need to understand these concepts. Supplement the assignment sheets with problems that cover concepts that require more study or that are more common in your area. Ensure that the students recognize the application of the math functions to electronics so that they will not view these concepts simply as math problems. **(Listening; seeing things in the mind's eye; applying technology; arithmetic/mathematics; science; problem solving; reasoning)**

- Demonstrate inductive circuits and provide real-world examples of their applications. Show how varying cores, windings, current, and other factors can affect inductance. Display motors, generators, and alternators and discuss their operation. Display and explain the design and operation of inductive components. Acquaint students with *choke* and similar terms that are used in the trade for inductive devices. Demonstrate mutual induction and explain its effects on a circuit. Allow the students to experiment with inductive circuits to explore changes in Q. Help the class to understand inductive reactance as related to resistance in both series and parallel circuits. **(Listening; applying technology; seeing things in the mind's eye; science; reasoning; application; acquiring and evaluating information)**

Suggested Activities

- Provide students with the same types of information and activities for capacitors and RC circuits as was done for inductors and RL circuits. Discuss reasons for using capacitors and RC circuits. Explain and demonstrate capacitive reactance and other characteristics of RC circuits. Discuss time constants for both RC and RL circuits. **(Listening; applying technology; seeing things in the mind's eye; science; reasoning; application; acquiring and evaluating information)**

- Display and demonstrate RCL circuits. Discuss the factors that determine whether an RCL circuit will be capacitive, inductive, or resonant. Discuss and demonstrate troubleshooting of all three types of AC circuits, using Job Sheet 15 to allow student practice and evaluation. Discuss and demonstrate applications for differentiator and integrator circuits, allowing students to brainstorm applications. Discuss and allow students to practice rectangular and polar notation methods. Display texts and data books that make use of these methods. **(Listening; seeing things in the mind's eye; science; arithmetic/mathematics; decision making; applying technology; maintenance and troubleshooting; problem solving; reasoning)**

- Display and demonstrate transformers. Show both power distribution and equipment internal transformers. Demonstrate the use of isolation transformers if not already done. Discuss transformer failures and service. Discuss single- and three-phase applications. Exhibit both types of circuits. Visit a power production facility to view the operation of generators, transformers, and three-phase distribution. Relate the total power production and distribution system to the user level and operation of electronic equipment. Discuss the need for power conditioning and how it is accomplished. **(Listening; seeing things in the mind's eye; science; applying technology; maintenance and troubleshooting; problem solving; reasoning; materials and facilities; system interrelationships)**

- Display and demonstrate the design and operation of filter circuits. Discuss ways of filtering and relate them to specific types of signals and electronic equipment. Emphasize the role of capacitors, inductors, resistors, and other components in such circuits. Have the students identify filter circuits in schematics and explain how the filtering function is achieved. Provide students with filtering problems and have them identify methods of providing the necessary filtering. **(Listening; seeing things in the mind's eye; science; applying technology; problem solving; reasoning; materials and facilities; selecting technology)**

Suggested Activities

Evaluation

- Discuss with students the use of the Unit Evaluation Form. Explain the rating scale that will be used for student evaluation.
- Copy written test and give to students as pretest. Record pretest score on the Unit Evaluation Form.
- Evaluate assignment sheets. See the evaluation criteria listed at the top of each assignment sheet and the component "Answers to Assignment Sheets."
- Evaluate job sheets. See the evaluation criteria listed at the top of each job sheet.
- Give and evaluate written test.
- Compile written-test, assignment-sheet, and job sheet scores on the Unit Evaluation Form. Include any additional assignments.
- Measure competency gains by comparing written pretest scores with posttest scores.
- Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas of improvement.
- Reteach and retest as required.

Instructions for Evaluating Student Performance

- When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily achieved the step(s) for each checkpoint area. If the student is unable to correctly complete the procedure, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria which have been provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

  Sample performance evaluation keys have been provided on the next page. Many other keys are available. Select one rating (grading scale) which best fits your program needs.

Suggested Activities

Option A

4 — Skilled—Can perform job with no additional training.
3 — Moderately skilled—Has performed job during training program; limited additional training may be required.
2 — Limited skill—Has performed job during training program; additional training is required to develop skill.
1 — Unskilled—Is familiar with process, but is unable to perform job.

Option B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Suggested Resources

Resources Used in Developing This Unit

- *Basic Electronics.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1987.
- *Communications Electronics.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1988.
- Davidson, Homer L. *Electronic Troubleshooting and Repair Handbook.* New York: McGraw-Hill, 1995.
- Davidson, Homer L. *Troubleshooting and Repairing Compact Disc Players.* 2nd Ed. New York, New York: TAB Books, 1994.
- *General Electronics Technician.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1987.
- *Graphic Symbols for Electrical and Electronics Diagrams.* New York: Institute of Electrical and Electronics Engineers, Inc., 1975.
- *Home Electronics.* Alexandria, Virginia: Time-Life Books, 1988.
- McMenamin, J. Michael. *Applied Electronic Devices and Analog ICs.* Albany, New York: Delmar Publishing, Inc., 1995.
- Newby, Bruce. *Electronic Signal Conditioning.* Oxford, England: Butterworth-Heinemann Ltd., 1994.
- Pallás-Areny, Ramón and John G. Webster. *Sensors and Signal Conditioning.* New York: John Wiley & Sons, Inc., 1991.

Suggested Activities

- Roehrig, Guido and Ulrich Schueller. *Upgrading and Maintaining Your PC.* Grand Rapids, Michigan: Abacus, 1991.
- Schuler, Charles A. *Electronics Principles and Applications.* 4th edition. New York: Glencoe Division, Macmillan/McGraw-Hill School Publishing Company, 1994.
- Simpson, Colin D. *Principles of DC/AC Circuits.* Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1996.
- Simpson, Colin D. *Principles of Electronics.* Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1996.
- Villanucci, Robert S., Alexander W. Avtgis, and William F. Megow. *Electronics Techniques: Shop Practices and Construction.* 5th edition. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1996.

Supplemental Resources

Print Media

- Data books and resource sheets from a variety of electronics components and equipment manufacturers.

Non-print Media

- *Alternating Current.* A ten-minute program produced in 1982 that shows the effects of AC using an ammeter. Available from: International Film Bureau, 332 S. Michigan Ave., Chicago, IL 60604.
- *Capacitance.* A short program covering the principles of capacitance and dielectrics. Available from: International Film Bureau, 332 S. Michigan Ave., Chicago, IL 60604.
- *Circuits, Coils, and Capacitors.* Part of the Applied Electronic series, this 1987 program discusses the operation of coils and capacitors and their use in AC circuits. Available from: Tel-A-Train; P.O. Box 4752; Chattanooga, TN 37405; 800-266-0113.
- *Electric Motors.* A 1986 program that discusses the construction and operating principles of electric motors. Available from: University of Illinois; Library Filmstrip Center; 608 E. Locust St.; Bloomington, IL 61701.

Suggested Activities

- *How Electric Motors Start and Run.* Part of the AAVIM electrical series, with specific application to this unit. Available from: American Association for Vocational Instructional Materials; 745 Gaines School Road; Athens, GA 30605; 800-228-4689.

- *Inductance.* Covers Lenz's Law, as well as self-induction and mutual induction. Available from: International Film Bureau, 332 S. Michigan Ave., Chicago, IL 60604.

Software

- *Circuit Analysis.* Through simulations and guided instruction, this program helps students to analyze both AC and DC circuits. Available from: CMA Microcomputer; 55722 Sante Fe Trail; Yucca Valley, CA 92284.

AC and AC Circuits
Unit 5

Answers to Assignment Sheets

Assignment Sheet 1—Determine Sine Wave Conversions

1. 110 volts
2. 35.35 volts
3. 70.7 volts
4. 63.7 volts
5. 440 volts
6. 42.4 volts
7. 86.7 volts
8. 47.3 volts
9. 25.9 volts
10. 277.4 volts

Assignment Sheet 2—Compute Period

1. 0.0083 seconds (8.3 milliseconds) or 1/120th of a second
2. 0.0000000096 seconds (9.6 nanoseconds) or 1/104,000,000th of a second
3. Decrease
4. 0.155 miles
5. 0.02 seconds or 1/50th of a second

Assignment Sheet 3—Determine Current Flow Direction

1. A to B
2. D to C
3. B
4. B to A
5. C to D
6. C
7. No flow

Assignment Sheet 4—Solve for Total Inductance

1. 15 mH
2. 3.33 H
3. 5 H
4. 5 mH
5. 8 mH

Answers to Assignment Sheets

Assignment Sheet 5—Compute Inductive Reactance

1. 7.54 ohms
2. 125.7 ohms
3. 50 ohms
4. 31.4 ohms
5. 30.1 ohms

Assignment Sheet 6—Compute Applied Voltage and Impedance of RL Circuits

1. a. 48 ohms d. 120 volts
   b. 52 ohms e. 2.5 amps
   c. 50 volts
2. a. 753.6 ohms d. 66 mA
   b. 760 ohms e. 66 mA
   c. 6.58 volts
3. a. 18 ohms
   b. 10 ohms
4. a. 26.8 ohms e. 2 amps
   b. 12 ohms f. 2 amps
   c. 8 volts g. 2 amps
   d. 40 volts
5. a. 41.23 ohms
   b. 10 ohms

Assignment Sheet 7—Compute Inductor Quality

1. 600
2. 377
3. No. Q does not have a unit of measure.
4. Inductor A
5. Increase

Assignment Sheet 8—Solve Time Constant Problems

1. 5
2. 63 (63.2) %
3. 1
4. 3
5. 100 volts (approximately 84%)
6. 4-5 amps
7. a. 0.05 amps or 50 mA
   b. 1 second
   c. 1.7 seconds
   d. 5 seconds

Answers to Assignment Sheets

Assignment Sheet 9—Compute Capacitance Values

1. a. 100 coulombs
   b. 100×10^{-6} coulombs
   c. 100×10^{-12} coulombs
   d. 5000×10^{-6} coulombs
2. 2.5 μF
3. 40 μF
4. 23.3 pF
5. 75 μF

Assignment Sheet 10—Compute RC Time Constants

1. 100 V
2. 8 amps
3. 5
4. a. 1 second
   b. 20 seconds
   c. 0.3 μseconds
   d. 1.41 seconds
5. a. 1.7 A
   b. 1.48 A
   c. 190 V
   d. 80.8 V
   e. 0.031 A
   f. 27 V
   g. 11.5 V

Assignment Sheet 11—Compute Capacitive Reactance

1. a. 1.59 ohms
   b. 266 ohms
   c. 0.049 milliohms
   d. 53 ohms
   e. 159.2 Kohms
2. 79 Kohms
3. Decreased
4. a. 22,608 radians/ second
   b. 15,700 radians/second
   c. Increase

Answers to Assignment Sheets

Assignment Sheet 12—Determine Phase Relationships in RC Circuits

1. Current a; voltage b
2. a. Resistive
   b. Capacitive
   c. RC
3. A power factor of 1 means that the circuit is a resistive circuit.

Assignment Sheet 13—Calculate Values of RC Circuits

1. a. 141.5 volts
   b. 141.5 volts
2. 56.6 ohms
3. a. 50 volts
   b. 36.9°
4. a. 98.1 ohms
   b. 140 ohms
   c. 714 ohms
   d. 71.4 volts
   e. 70 volts
   f. 45.6°
   g. 0.699

Assignment Sheet 14—Solve for Reactance

1. a. -5, inductive
   b. -5, capacitive
   c. 0, resonant
   d. -5, capacitive
   e. 5, inductive
2. a. Capacitive
   b. Inductive
   c. Inductive
   d. Inductive
   e. Inductive

Assignment Sheet 15—Solve for Impedance

1. a. 5 ohms
   b. 0 ohms
2. a. 8.94 ohms
   b. -8 ohms
3. a. 22.36 ohms
   b. -10 ohms

Assignment Sheet 16—Solve for Parameters of Resonant Circuits

1. 57 Hz
2. 0.5 A

Answers to Assignment Sheets

3. 713 ohms
4. 713 ohms
5. 356.5 volts
6. 356.5 volts
7. 50 volts
8. 25 W
9. 7.13
10. 8 Hz

Assignment Sheet 17—Solve Problems Related to Parallel RCL Circuits

1. 1997 ohms
2. 400 ohms
3. 1 amp
4. 0.25 amps
5. 0.5 amps
6. 1.02 amps
7. 98 ohms
8. 100 watts
9. 102 watts
10. 0.98
11. 11.3°

Assignment Sheet 18—Analyze a Parallel Resonant Circuit

1. a, c, d
2. a, c
3. b
4. c
5. b
6.
    a. 455 KHz
    b. 100
    c. 10 mA
    d. 0.1 mA
    e. 10 Kohms
    f. 0.001 watts
    g. 4.55 KHz

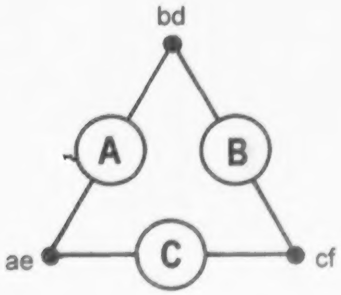
Assignment Sheet 19—Calculate the Power in Three-Phase Circuits

1. 12.4 KVA
2. 2.08 KVA
3. 24.9 KVA
4. 7.62 KVA
5. 6.5 KVA

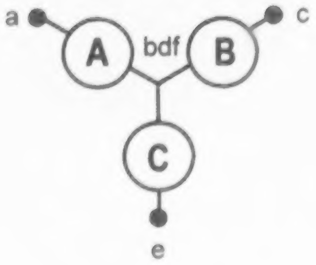
Answers to Assignment Sheets

Assignment Sheet 20—Determine Three-Phase Transformer Connections

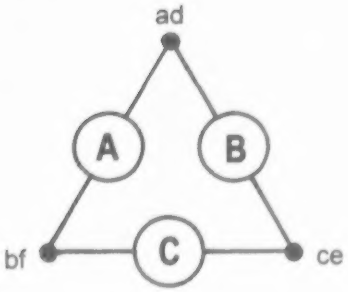
1.



2.

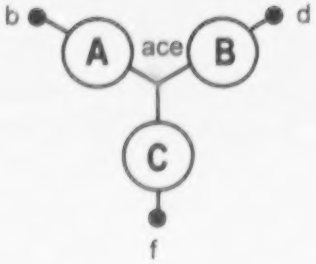


3.

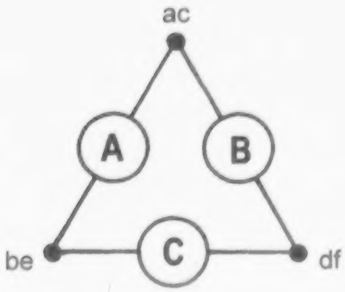


Answers to Assignment Sheets

4.



5.



AC and AC Circuits
Unit 5

Answers to Written Test

1.

a.	5	f.	3	k.	15	p.	11
b.	16	g.	7	l.	9	q.	12
c.	13	h.	17	m.	4	r.	2
d.	8	i.	14	n.	1		
e.	6	j.	18	o.	10		

2. (Answer should include the essence of the following statement.)

Because the operation of electronic equipment requires the use of motors, lamps, speakers, displays, and other devices that function more efficiently when powered by alternating current and because of the availability of alternating current, most electronic equipment uses alternating current to power AC devices and rectifies alternating current to provide required DC power.

3.
   a. Neutral ground—Use of a third wire in a power cord and power line that connects to ground
   b. Isolation transformer—Device that provides power to equipment while also interrupting the equipment's direct connection to the power line
   c. Polarized plug—Equipment power plug built so that it can only be inserted into an outlet in one way

4.

a.	11	e.	15	i.	14	m.	9
b.	3	f.	8	j.	4	n.	12
c.	13	g.	6	k.	2	o.	7
d.	10	h.	5	l.	1		

5.
   a. S
   b. N

6.
   a. In-phase—Condition in which the maximum displacements of two waveforms occur at the same time
   b. Out-of-phase—Condition in which maximum displacement of a second waveform occurs after the maximum displacement of another waveform

7.
   a. 3
   b. 1
   c. 2

8.
   a. Inductance
   b. EMF
   c. L
   d. Henry (H)

Answers to Written Test

9. a. When current flows in an inductor, a magnetic field is produced that moves with the current.
   b. The movement of the magnetic field induces a voltage back into the wire counter to the original current that is called *counter EMF*.
   c. Self-induction occurs when the current increases or decreases.
   d. Counter EMF opposes changes in current flow.

10. a. When an AC voltage is applied to an inductor, a magnetic field is produced that induces an AC voltage that is 180° out of phase with the applied voltage.
    b. The waveform of the induced voltage has the same characteristics as the applied voltage wave form.
    c. The counter EMF of the circuit will be 90° out of phase with the induced current.
    d. The current flowing in an inductive circuit is directly proportional to the applied voltage.
    e. The current flowing in an inductive circuit is inversely proportional to the inductive reactance of the circuit.
    f. The formula for calculating current in an inductive circuit is

$$I = \frac{E}{X_L}$$, where X_L is the inductive reactance

11. a. With pure inductance, no power is dissipated; however, due to conductor resistances and other values that prevent the construction of pure inductors, power dissipation occurs in actual inductive circuits.
    b. Because power is dissipated in the resistances, standard power dissipation formulas can be used for inductive circuits.

12. a. Armature
    b. Electrical flow
    c. Slip rings
    d. Brush
    e. Load circuit
    f. Armature
    g. Direction
    h. Parallel, parallel
    i. Magnets
    j. Coils

13. a. Magnetic
    b. Armature
    c. Electromagnet
    d. Repel
    e. Polarity
    f. Shaft

14. a, b, c, d

15. a. 1
    b. 2
    c. 3
    d. 4

Answers to Written Test

16. a. Delta
    b. Wye

17. a. 120 volts, two-wire
    b. 120/240 volts, three-wire with additional power capacity of two transformers
    c. 240 volts, two-wire
    d. High-voltage, boosted by 240 volts
    e. 120/240 volts, three-wire
    f. 208 volts, two-wire from 240-volt through autotransformer

18. c

19. a. Opposition
    b. Directly
    c. Directly
    d. X_L
    e. Ohm
    f. $X_L = 2\pi fL$

20. a. Mutual induction is the process by which one current carrying conductor causes a voltage to be induced in another conductor.
    b. The amount of mutual inductance between adjacent conductors depends on the degree of coupling between the conductors.
    c. The amount of mutual inductance between adjacent conductors depends on the inductance value of each conductor.
    d. The symbol for mutual induction is L_M.
    e. The unit of measure for mutual induction is the Henry, where one Henry represents a condition in which a current change of one ampere per second will induce a voltage of one volt in the other conductor.

21. a. The number of turns in the coil
    b. The permeability of the core material
    c. The length of the coil

22. a. Magnetic field
    b. Directly
    c. Q
    d. Resistance
    e. $Q = \frac{X_L}{R}$
    f. Increases

23. a. $L_t = L_1 + L_2 + L_3$
    b. $L_t = L_1 + L_2 + 2L_M$
    c. $L_t = L_1 + L_2 - 2L_M$

Answers to Written Test

d. $L_t = \frac{L_1 \times L_2}{L_1 + L_2}$

24. a. Voltage drops
b. Resistance
c. R
d. Lags, leads
e. $E_a = \sqrt{E_R^2 + E_L^2}$

25. a. The total opposition to flow offered by both the resistor and the inductor is called impedance.
b. Ohms
c. Z
d. $Z = \frac{E_a}{I_t}$
e. $Z = \sqrt{R^2 + X_L^2}$

26. tangent $\theta = \frac{X_L}{R}$

27. a. Store
b. C
c. Farad
d. Coulomb
e. $C = \frac{Q}{E}$
f. Capacitance
g. Dielectric

28. a. The total area of the metal plates
b. The distance between the metal plates
c. The strength of the dielectric

29. a. Classified by adjustability
b. Classified by type of dielectric
c. Classified as electrolytic or nonelectrolytic
d. Classified by capacitance value

30. a, b, c, d, e

31. a. 4
b. 2
c. 3
d. 1

Answers to Written Test

32. a. Less, smallest

b. $C_t = \dfrac{C_1 \times C_2}{C_1 + C_2}$

c. Greater

d. $C_t = C_1 + C_2 + C_3$

33. a. Resistive-capacitive

b. 63.2

c. Resistance

d. $T = R \times C$

e. Five

34. a. Applied voltage

b. Lead

c. Maximum

d. Maximum

e. Resistor

f. Lags

g. $E_a = \sqrt{E_R^2 + E_C^2}$

35. a. Power is actually only dissipated in the resistive portion of an RC circuit; however, power appears to be consumed throughout the circuit when Watt's Law ($P = IE$) is applied, leading engineers and technicians to refer to this dissipated power as *apparent power*.

b. The relationship between true power and apparent power in an AC RC circuit is referred to as the *power factor* and is determined by dividing true power by apparent power.

c. The power factor is also equal to the cosine of the phase angle, which represents the ratio of resistance to impedance, and can be expressed in the formula:

$$\text{cosine } \theta = \frac{R}{Z}$$

36. a. The total opposition to flow offered by both the resistor and the capacitor is called impedance.

b. Ohms

c. Z

d. $Z = \dfrac{E_a}{I_t}$

e. $Z = \sqrt{R^2 + X_C^2}$

Answers to Written Test

37. $\theta = \arctan \frac{X_C}{R}$ or $\theta = \arctan \frac{E_C}{E_R}$

38.
- a. Opposition
- b. Inversely
- c. Inversely
- d. X_c
- e. Ohm
- f. $X_C = \frac{1}{2\pi fC}$

39.
- a. $I = E/R$
- b. $Z = \frac{E_a}{I_t}$
- c. $Z = \sqrt{R^2 + X_C^2}$
- d. $X_{Ct} = X_{C1} + X_{C2} + X_{C3}$

40.
- a. $I = E/R$
- b. $I = E/X_C$
- c. $I_t = \sqrt{I_R^2 + I_C^2}$
- d. $Z = \frac{E_a}{I_t}$
- e. $Z = \frac{RX_C}{\sqrt{R^2 + X_C^2}}$
- f. $\frac{1}{X_{Ct}} = \frac{1}{X_{C1}} + \frac{1}{X_{C2}} + \frac{1}{X_{C3}}$

41. a, b, c, e

42.
- a. Resistive-capacitive-inductive
- b. Reactance
- c. Inductive
- d. Capacitive
- e. Resonant
- f. $X_t = X_L - X_C$
- g. $Z = \sqrt{R^2 + X_t^2}$

Answers to Written Test

h. Current
i. Leads
j. Lags
k. $V_t = \sqrt{V_L^2 + V_C^2}$
l. $E_a = \sqrt{V_R^2 + V_X^2}$

43. a. Impedance is at its minimum value.
b. Circuit current is at its maximum level.
c. The phase angle between voltage and current is zero.
d. V_L and V_C are equal and are larger than E_a.
e. $f_r = \dfrac{1}{2\pi\sqrt{LC}}$
f. $Q = \dfrac{X}{R}$
g. $BW = \dfrac{f_r}{Q}$

44. a. Resistive-capacitive-inductive
b. Voltage
c. $I = E_a/R$
d. Leads
e. $I = E_a/X_C$
f. Lags
g. $I = E_a/X_L$
h. Reactive
i. Tank circuit
j. $I_t = \sqrt{I_R^2 + I_X^2}$
k. $Z = \dfrac{E_a}{I_t}$

45. a. Impedance is at its maximum value.
b. Circuit current is at its minimum level and equals the resistive current.
c. The phase angle between applied voltage and total current is zero.
d. V_L and V_C are equal and are larger than E_a.
e. $f_r = \dfrac{1}{2\pi\sqrt{LC}}$
f. $Q = \dfrac{X_L}{R}$

Answers to Written Test

g. $BW = \frac{f_r}{Q}$

46. a. 5
  b. 1
  c. 4
  d. 6
  e. 3
  f. 2

47.
- Amplification (any three of the following)
  a. Amplifiers
  b. Integrator circuits
  c. Differentiator circuits
  d. Inductors
- Filtering (any three of the following)
  a. Low-pass filters
  b. High-pass filters
  c. Band-pass filters
  d. Band-stop filters
  e. Rectifier filters
  f. Active filters
- Impedance matching (any two of the following)
  a. Resistors
  b. Inductors
  c. Active filters
- Modulation/ Demodulation (any two of the following)
  a. Frequency modulators/demodulators
  b. Amplitude modulators/demodulators
  c. Pulse amplitude modulators/demodulators
- Conversion (any three of the following)
  a. Oscillators
  b. Analog-to-digital converters
  c. Voltage-to-frequency converters
  d. Frequency-to-voltage converters
  e. Voltage-to-current converters
  f. Current-to-voltage converters

48. a. 4
  b. 2
  c. 3
  d. 1

49. a, d, e, f

Answers to Written Test

50. a. π-filter
    b. T-filter
    c. L-filter

51. a. 4
    b. 5
    c. 2
    d. 1
    e. 3

52. a. L
    b. H

53. a. The best efficiency of power transfer occurs when the source impedance is equal to the load impedance.
    b. In a circuit, impedance is normally matched through the use of external resistors.

54. a. Rotation
    b. Counterclockwise
    c. Clockwise
    d. Inductive
    e. Capacitive
    f. Summation

55. a. Phase angle
    b. Counterclockwise
    c. Clockwise
    d. Inductive
    e. Capacitive
    f. Trigonometric

AC and AC Circuits
Unit 5

Written Test

Name ________________________________ Date ____________ Score ____________

1. Match terms associated with AC and AC circuits to their correct definitions. Write the corresponding numbers on the blanks provided.

______a. Design of circuits so that their impedances are equal or can be adjusted to be equal to each other

______b. A parallel resistive-capacitive-inductive circuit in which the inductive and capacitive values are equal

______c. Condition in which complementary characteristics, such as inductance and capacitance, of an AC circuit are equal

______d. Extent to which one AC characteristic precedes another in time

______e. The value of a quantity that varies over time at a specified point in time

______f. Material that is a nonconductor of electricity

______g. Extent to which one AC characteristic follows another in time

______h. Numerical value that represents that steady rate of change of a variable over time

______i. Term applied to voltage or current to indicate effective voltage or current, being descriptive of the mathematical relationship between effective voltage and effective current and the average of all instantaneous values of a waveform

1. Bandwidth
2. Coupling
3. Dielectric
4. Function
5. Impedance matching
6. Instantaneous value
7. Lag
8. Lead
9. Linear
10. Phase angle
11. Phase shift
12. Propagation
13. Resonance
14. Root mean square
15. Sinusoidal
16. Tank circuit
17. Time constant
18. Vector

Written Test

_______j. Method of representing a value to show that it has both direction and quantity and that can be mathematically combined (added, subtracted, etc.) with another such value to determine the net result

_______k. Having the shape and properties of a sine curve; that is, a curve in which the ratio of the y-value to the x-value can be described by the sine of a triangle defined by the curve

_______l. Relationship between variables in which the relationship remains constant so that a graph of their variation produces a straight line

_______m. A value that is related to a second value so that their relationship can be described mathematically such that if one value is known the other can be determined

_______n. A signal frequency or a range of frequencies over which a device or circuit transmits AC energy with no significant loss

_______o. Measure of the difference of the identical positions of two characteristics of AC power

_______p. Condition in which the phase angle of two AC characteristics is other than 0° or the act of causing the phase angle of two AC characteristics to change

_______q. Transmission of energy

_______r. Linking of two or more circuits or devices by electrostatic lines of force (capacitive coupling), electromagnetic lines of force (inductive coupling), or direct connection (direct coupling) to allow energy to be transferred between the circuits or devices

Written Test

2. Explain the role of alternating current in the operation of electronic equipment.

____

____

____

3. Describe methods for providing safety grounding for AC circuits. For each key word or phrase below, describe how that word or phrase applies to methods for providing safety grounding for AC circuits.

   a. Neutral ground—______________________________

   ____

   b. Isolation transformer—__________________________

   ____

   c. Polarized plug—________ ________________________

   ____

4. Match characteristics of an AC waveform to their correct descriptions. Write the corresponding numbers on the blanks provided.

   ______a. A portion of the height of a waveform as measured at various points in the waveform

   ______b. Mean electrical potential of an alternation, mathematically defined as 0.636 times the alternation's peak value

   ______c. Time required for the waveform to build from 10 percent of amplitude to 90 percent of amplitude

   ______d. Wave amplitude as the combined height of both alternations

   ______e. Portion of the waveform showing decreasing amplitude

   1. Alternation
   2. Amplitude
   3. Average voltage
   4. Cycle
   5. Effective voltage
   6. Fall time
   7. Frequency
   8. Leading edge
   9. Peak

______f. Portion of the waveform showing increasing amplitude

______g. Time required for the waveform to drop from 90 percent of amplitude to 10 percent of amplitude

______h. AC alternation value that will produce the same amount of heat energy in a resistance as a DC value, mathematically defined as 0.707 times the alternation's peak value

______i. Form taken by the displayed waveform

______j. One full set of values for a repetitive waveform as measured from one point on a waveform to the corresponding point on the next waveform

______k. Height of the waveform across a full cycle

______l. One half of a cycle

______m. Height of one alternation

______n. Time required to complete one cycle

______o. Number of cycles completed in one second

10. Peak-to-peak
11. Percent amplitude
12. Period
13. Rise time
14. Shape
15. Trailing edge

5. Distinguish between sinusoidal and nonsinusoidal waveforms. Write an "S" beside the statement below that describes a sinusoidal waveform and an "N" beside the statement below that describes a nonsinusoidal waveform.

______a. Periodic wave whose amplitude is a function of the sine of a linear quantity such as phase or time

______b. Periodic wave that does not exhibit a constant functional relationship between its amplitude and any linear value associated with the propagation of the wave or whose functional relationship is other than a sine relationship

Written Test

6. Describe AC waveform phase relationships. For each key word or phrase below, describe how that word or phrase applies to AC waveform phase relationships.

   a. In-Phase--____

   ____

   b. Out-of-phase--____

   ____

7. Match various types of circuits to correct descriptions of their phase angles.

   ______a. Has a phase angle of 0º

   ______b. Current leads voltage by a phase angle of 90º

   ______c. Voltage leads current by a phase angle of 90º

   1. Purely capacitive circuit
   2. Purely inductive circuit
   3. Purely resistive circuit

8. Complete statements regarding inductance.

   a. ______________ is the physical property of a component or circuit that opposes any change in the current present in that component or circuit.

   b. As a result of inductance, when the current in a conductor is changed, ______________ is induced.

   c. The symbol for inductance is ______________.

   d. The unit of measurement for inductance is the ______________.

9. Describe the process of self-induction. For each key word or phrase below, describe how that word or phrase applies to the process of self-induction.

   a. When current flows in an inductor—________________________________

   ____

   b. Movement of the magnetic field—_________________________________

   ____

c. Increasing or decreasing current flow— ______________________________

____

d. Opposition to changes in current flow— ______________________________

____

10. Describe the relationship between current and voltage in an inductive AC circuit. For each key word or phrase below, describe how that word or phrase applies to the relationship between current and voltage in an inductive AC circuit.

a. When AC voltage is applied to an inductor— ______________________________

____

b. Characteristics of induced voltage waveform— ______________________________

____

c. Counter EMF phasing— ______________________________

____

d. Relationship between inductive circuit current and applied voltage—____________

____

e. Relationship between inductive circuit current and inductive reactance —________

____

f. Formula for calculating current in an inductive circuit—______________________

____

11. Describe power in an inductive circuit. For each key word or phrase below, describe how that word or phrase applies to power in an inductive circuit.

a. Power dissipation—______________________________

____

b. Use of standard power formulas—______________________________

____

Written Test

12. Complete statements regarding the operation of a generator.
    a. A conductive loop called an _______________ rotates within a magnetic field.
    b. The rotation of the armature induces _______________ in the loop.
    c. Electrical current is carried to one of the _______________ connected to each end of the armature.
    d. The slip ring is in contact with a conductive _______________ that is connected to the load circuit.
    e. Electricity flows into the _______________ to provide power to the load.
    f. Electrical flow continues through the load circuit to the other slip ring and back into the _______________.
    g. As the armature continues to rotate, the _______________ of electrical flow and the amount of induced current varies.
    h. When the armature is _______________ to the magnetic field, there is no electrical flow; once the armature moves past _______________, the current flow reverses direction.
    i. If the number of armature coils and the number of sets of _______________ are the same, the electricity produced will all be of the same phase and the generator is called a *single-phase* generator.
    j. Many AC generators use three armature _______________ for each set of magnets, resulting in the production of *three-phase power*.

13. Complete statements regarding the operation of an AC motor.
    a. The motor contains a field structure that provides a constant _______________ field within the motor housing.
    b. A rotating _______________ is positioned within the magnetic field, consisting of a conductive loop.
    c. When electricity is applied to the armature, the loop becomes an _______________.

d. The north pole of the armature and the north pole of the field structure ________________ each other, as do the south poles, causing the armature to rotate.

e. When the AC electricity alternates, the ________________ of the armature changes so that the like poles again repel reach other, causing the armature to continue to rotate as long as power is applied.

f. The armature is connected to a ________________ that is used to transfer mechanical power to perform work.

14. Select from a list roles of transformers in the operation of electronic equipment. Write an "X" beside each correct role listed below.

______a. Voltage reduction

______b. Current reduction

______c. Circuit isolation

______d. Circuit coupling

______e. Phase shifter

15. Match types of transformers to their correct descriptions. Write the corresponding numbers on the blanks provided.

______a. Transformer without a metal core, generally used in low-power, high-frequency applications

______b. Transformer whose primary and secondary windings use a common core and are physically connected

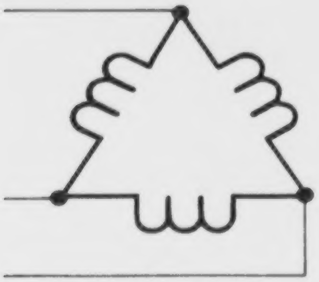
______c. Transformer with a metal core (often laminated iron or steel), generally used in high-power, low-frequency applications

______d. Transformer with a ring-shaped core

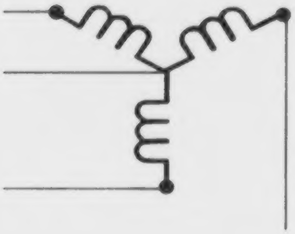
1. Air-core
2. Autotransformer
3. Iron-core
4. Toroidal

16. Identify types of three-phase circuits. In the space provided, indicate whether the description and drawing are for a wye or delta three-phase circuit.

______a. Voltage across each load member is the full-line voltage; amperage in each load member is 1.732 x line amperage

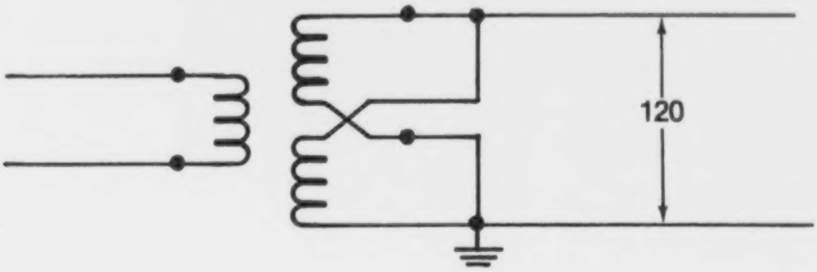


______b. Amperage in each load member is the full-line amperage; voltage across each member is 1.732 x line voltage

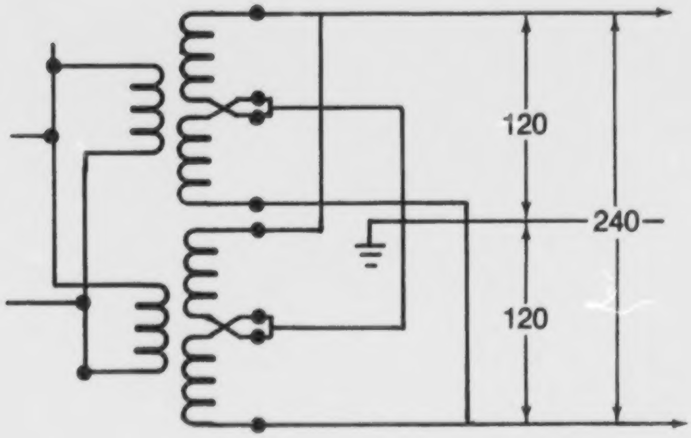


17. Identify types of single-phase transformer connections.

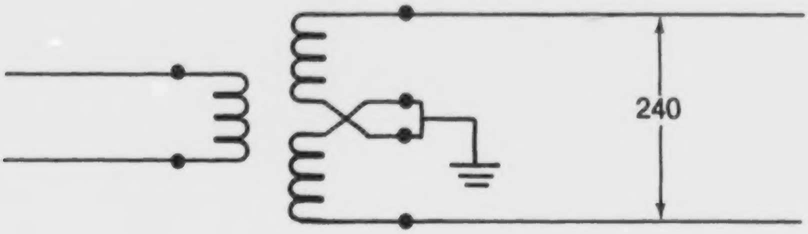
a. ______________________________



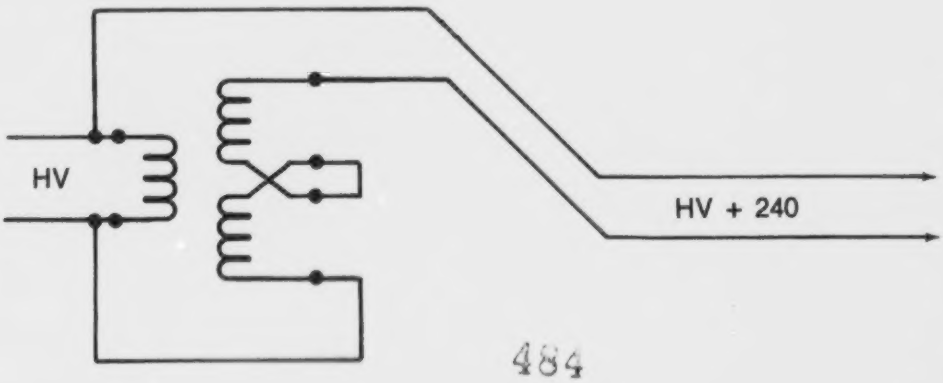
b. ______________________________



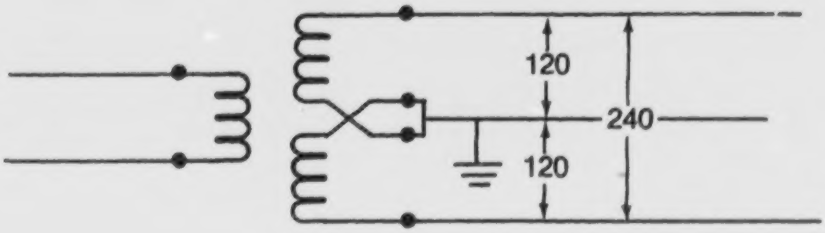
c. ______________________________



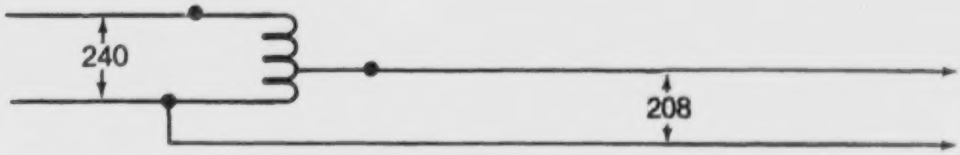
d. ______________________________



e. ____



f. ____



18. Select true statements about the time constant of inductive circuits. Write an "X" beside each statement below that is correct.

_____a. The time constant for inductive circuits represents the time required for the current to change by 62.3 percent.

_____b. The time constant is a function of the inductance and capacitance of the circuit.

_____c. The formula for the time constant is T = L/R.

_____d. It takes six time constant intervals for current to rise from zero to its maximum or to fall from its maximum to zero for any given inductance value.

19. Complete statements about inductive reactance. Write the missing word or phrase in the space provided or circle the correct choice given in parentheses (choice 1, choice 2).

a. Inductive reactance is the _______________ to AC.

b. Inductive reactance is (directly, inversely) proportional to the inductance of the applied voltage.

c. Inductive reactance is (directly, inversely) proportional to the frequency of the current.

d. Inductive reactance is represented by the symbol ______________.

e. The unit of measure for inductive reactance is the ______________.

f. Inductive reactance can be calculated by the formula ______________.

20. Describe the process of mutual induction. For each key word or phrase below, describe how that word or phrase applies to the process of mutual induction.

a. What mutual induction is—______________________________________

____

b. Coupling—____

____

c. Inductance value of each conductor—______________________________

____

d. Symbol for mutual induction—______________________________

e. Unit of measure—______________________________________

21. List factors that influence the strength of inductors.

a. ______________________________

b. ______________________________

c. ______________________________

22. Complete statements regarding the quality of inductors. Write the missing word or phrase in the space provided or circle the correct choice given in parentheses (choice 1, choice 2).

a. The quality of a coil is the ratio between the energy stored in the ______________ of the coil as compared to the energy dissipated due to the resistance in the wire of the coil.

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b. Because the energy of the coil's magnetic field is (directly, inversely) proportional to the inductive reactance of the coil, quality can also be viewed as a comparison of the coil's inductive reactance and the resistance in its wiring.

c. Inductor quality is represented by the letter ________________.

d. Because inductor quality is a comparison of one ________________ to another, there is no unit of measure.

e. Inductor quality can be expressed in the formula ________________.

f. Because induction quality is directly proportional to inductive reactance, ________________ in inductive reactance will result in improved inductor quality.

23. State formulas for connecting inductors in series and parallel.

a. Two or more inductors connected in series without mutual inductance

____

b. Two or more inductors connected in series with mutual inductance in which magnetic fields aid each other

____

c. Two or more inductors connected in series with mutual inductance in which magnetic fields oppose each other

____

d. Two inductors connected in parallel ________________________________

24. Complete statements about the relationship between current and voltage in an RL circuit. Write the missing word or phrase in the space provided or circle the correct choice given in parentheses (choice 1, choice 2).

a. AC flow in an RL circuit causes ________________ across the resistor and the inductor.

b. The voltage drop across the ________________ can be found using Ohm's Law.

c. The voltage drop across the inductor can be found using Ohm's Law with X_L substituted for ________________.

d. The circuit current in an RL circuit (leads, lags) the applied voltage by 90° and the voltage across the inductor (leads, lags) the current by 90°.

e. The formula for applied voltage in an RL circuit is ______________.

25. Describe impedance in RL circuits. For each key word or phrase below, describe how that word or phrase applies to impedance in RL circuits.

a. What is impedance— ____

____

b. Unit of measure—____

c. Symbol for impedance—____________________________________

d. Formula as a variation of Ohm's Law—_______________________

e. Formula if resistance and inductive reactance are known—______________

26. State the formula for determining phase shift in RL circuits.

____

27. Complete statements regarding capacitance.

a. Capacitance is the property of a device or circuit that allows it to ______________ electrical energy as an electrostatic field.

b. The symbol for capacitance is ______________.

c. The unit of measure for capacitance is the ______________.

d. One farad is equal to a capacitance such that one ______________ of charge is stored when one volt is applied.

e. Capacitance can be calculated with the formula ______________.

f. The principle device used to provide specific levels of ______________ in a circuit is called a capacitor and is able to discharge the collected electrons at a later time.

g. Capacitors are constructed of two metal plates separated by a ______________.

Written Test

28. List factors that influence the capacitance of a capacitor.

a. ______________________________

b. ______________________________

c. ______________________________

29. Name ways of classifying capacitors.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

30. Select from a list uses of capacitors in electronic circuits. Write an "X" beside each statement below that is a correct use of capacitors in electronic circuits.

______a. Coupling circuits

______b. Storing charge

______c. Releasing charge

______d. Multiplying voltage

______e. Filtering signals

31. Match capacitor defects to their correct descriptions. Write the corresponding numbers on the blanks provided.

______a. The rated capacitance value changes due to a manufacturing defect or abuse of the capacitor, such as excessive temperature or voltage

______b. The leads become detached from the metal plates

______c. The dielectric is punctured or otherwise fails

______d. A resistive path forms in the dielectric

1. Leakage
2. Open
3. Short
4. Value change

32. State rules for connecting capacitors in series and parallel. Write the formula in the space provided or circle the correct choice given in parentheses (choice 1, choice 2).

    a. When two or more capacitors connected in series, the total capacitance is (greater, less) than the capacitance of the (largest, smallest) capacitor.

    b. Two or more capacitors connected in series network, the formula for total capacitance is

    ____

    c. The total capacitance of a parallel combination is always (greater, less) than the value of any capacitor in the parallel network.

    d. Two or more capacitors connected in parallel network, the formula for total capacitance is

    ____

33. Complete statements regarding time constants in an RC circuit.

    a. A circuit that contains both resistive elements and capacitors is referred to as a _______________ circuit.

    b. Capacitors charge and discharge at a time constant rate of _______________ percent.

    c. Both the value of the capacitor and the value of _______________ along the charge/discharge path affect the time interval constant required for a capacitor in a circuit to charge or discharge.

    d. The formula for an RC time constant is _______________.

    e. It takes approximately _______________ of the time constant intervals for a capacitor to fully charge or discharge.

34. Complete statements regarding the relationship between current and voltage in an RC circuit. Write the missing word or phrase in the space provided or circle the correct choice given in parentheses (choice 1, choice 2).

    a. When voltage is applied to an RC circuit, the voltage developed across the capacitor (E_C) is equal to and in phase with the _______________.

    b. The sine wave current developed in the circuit will (lead, lag) the E_a and E_C voltages by 90°.

c. When E_a and E_C are at their (maximum, minimum) values for their positive and negative alternations, current in the circuit is zero.

d. When E_a and E_C are at zero, current in the circuit is at its (maximum, minimum).

e. The voltage drop across the ________________ is in phase with the current in the circuit.

f. The voltage across the capacitor (leads, lags) the current flowing in the circuit by 90°.

g. The formula for applied voltage in an RC circuit is ________________.

35. Describe power in an RC circuit. For each key word or phrase below, describe how that word or phrase applies to power in an RC circuit

a. Apparent power—____

____

b. Power factor—____

____

c. Power formula—____

36. Describe impedance in RC circuits. For each key word or phrase below, describe how that word or phrase applies to impedance in RC circuits.

a. What impedance is—____

____

b. Unit of measure—____

c. Symbol for impedance —____

d. Formula if current and voltage are known—__________________________

e. Formula if resistance and inductive reactance are known—______________

37. State the formula for determining phase shift in RC circuits.

____

38. Complete statements regarding capacitive reactance. Write the missing word or phrase in the space provided or circle the correct choice given in parentheses (choice 1, choice 2).

   a. Capacitive reactance is the ______________ to AC current flow offered by a capacitor.

   b. Capacitive reactance is (directly, inversely) proportional to the capacitance of the capacitor voltage.

   c. Capacitive reactance is (directly, inversely) proportional to the frequency of the applied voltage.

   d. Capacitive reactance is represented by the symbol ______________.

   e. The unit of measure for capacitive reactance is the ______________.

   f. Capacitive reactance can be calculated by the formula ______________.

39. State formulas used to determine the characteristics of series RC circuits.

   a. The current in an RC series circuit is determined by the formula:

   ____

   b. The impedance of the series RC circuit is determined by the formula:

   ____

   c. If the resistance and capacitive reactance are known, impedance can be determined with the formula:

   ____

   d. Capacitive reactances in series:

   ____

40. State formulas used to determine the characteristics of parallel RC circuits.

   a. The current in the resistive branch of an RC parallel circuit is determined by the formula:

   ____

b. The current in the capacitive branch of an RC parallel circuit is determined by the formula:

____

c. Total current is determined with the formula:

____

d. The impedance of the parallel RC circuit is determined by the formula:

____

e. If the resistance and capacitive reactance are known, impedance can be determined with the formula:

____

f. Capacitive reactances in parallel are combined using the formula:

____

41. Select from a list uses of capacitive circuits. Write an "X" beside each statement below that is a correct use of capacitive circuits in electronic devices.

______a. Voltage divider

______b. Low-pass filter circuit

______c. High-pass filter circuit

______d. Multiplying voltage

______e. Phase shifter

42. Complete statements regarding the characteristics of series RCL circuits. Write the missing word or phrase in the space provided or circle the correct choice given in parentheses (choice 1, choice 2).

a. Series _______________ circuits contain resistance, capacitance, and inductance components connected in series.

b. Total _______________ in the circuit is a combination of X_L and X_C.

c. When X_L is greater than X_C, the circuit behaves as an (inductive, capacitive) circuit.

d. When X_C is greater than X_L, the circuit behaves as a (inductive, capacitive) circuit.

e. When X_L and X_C are equal, the circuit appears to be resistive and is referred to as ________________.

f. Net reactance (X_t) is equal to ________________.

g. Impedance in an RCL circuit is calculated as ________________.

h. Voltage across the resistance (V_R) is in phase with the circuit ________________.

i. Voltage across the inductor (V_L) (leads, lags) the circuit current by 90°.

j. Voltage across the capacitor (V_C) (leads, lags) the circuit current by 90°.

k. Reactive voltage (V_t) is determined with the formula ________________.

l. The applied voltage is determined with the formula ________________.

43. Describe the resonant characteristics of a series RCL circuit. For each key word or phrase below, describe how that word or phrase applies to the resonant characteristics of a series RCL circuit.

a. Impedance value—____

____

b. Circuit current value—____________________________________

____

c. Phase angle between voltage and current—______________________

____

d. Relationship among V_L, V_C, and E_a—_________________________

____

e. Formula for resonance frequency—______________________________

f. Formula for circuit quality—____

g. Formula for bandwidth—____

44. Complete statements regarding the characteristics of parallel RCL circuits. Write the missing word or phrase in the space provided or circle the correct choice given in parentheses (choice 1, choice 2).

a. Parallel ____________________ circuits contain resistance, capacitance, and inductance components connected in parallel.

b. Current in the resistive branch is in phase with the _______________.

c. The current in the resistive branch of an RCL parallel circuit is determined by the formula _______________.

d. Current in the capacitive branch (leads, lags) the voltage by 90°.

e. The current in the capacitive branch of an RCL parallel circuit is determined by the formula __________________.

f. Current in the inductive branch (leads, lags) the voltage by 90°.

g. The current in the inductive branch of an RCL parallel circuit is determined by the formula _______________.

h. The _______________ current (I_X) is the difference between the current in the inductive branch (I_X) and the current in the capacitive branch (I_C).

i. When the inductive effects equal the capacitive effects, the circuit is resonant and is often referred to as a _______________.

j. Total current is determined with the formula _______________.

k. The impedance of the parallel RCL circuit is determined by the formula _______________.

Written Test

45. Describe the resonant characteristics of a parallel RCL circuit. For each key word or phrase below, describe how that word or phrase applies to the resonant characteristics of a parallel RCL circuit.

a. Impedance value—______________________________

____

b. Circuit current value—______________________________

____

c. Phase angle between voltage and current—______________________________

____

d. Relationship among V_L, V_C, and E_a—______________________________

____

e. Formula for resonance frequency—______________________________

f. Formula for circuit quality—______________________________

g. Formula for bandwidth—______________________________

46. Match processes for conditioning signals to their correct descriptions. Write the corresponding numbers on the blanks provided.

______a. Causing the impedance of the source signal and the load signal to be equal or nearly equal

______b. Increasing of signal strength

______c. Separation of selected frequencies or groups of frequencies

______d. Control of periodic aspects of a signal such as amplitude, frequency, or pulse width

______e. Recovering original signal characteristics from a modulated signal

______f. Changing one signal characteristic to another

1. Amplification
2. Conversion
3. Demodulation
4. Filtering
5. Impedance matching
6. Modulation

Written Test

47. List devices and circuits involved in analog signal conditioning.

- Amplification

  a. ____________________________________

  b. ____________________________________

  c. ____________________________________

- Filtering

  d. ____________________________________

  e. ____________________________________

  f. ____________________________________

- Impedance matching

  g. ____________________________________

  h. ____________________________________

- Modulation/Demodulation

  i. ____________________________________

  j. ____________________________________

- Conversion

  k. ____________________________________

  l. ____________________________________

  m. ____________________________________

48. Match devices and circuits involved in digital signal conditioning to their correct descriptions. Write the corresponding numbers on the blanks provided.

______a. Receives digital input signals and conditions them in accordance with internal software processing instructions to produce a digital output signal

______b. Takes periodic samples of an analog signal and represents the sample taken at a point in time as a digital value

______c. Receives digital inputs on which a logical combining is performed to produce a digital output signal

______d. Produces output signals based on current and past input signals and, in some cases, past output signals

1. Digital filter
2. Digital-to-analog converter
3. Logic gate
4. Programmable logic controller

49. Select from a list correct statements about AC differentiator and integrator circuits. Write an "X" beside each item below that is a correct statement about AC differentiator and integrator circuits.

______a. A differentiator circuit contains a series capacitor and a shunt resistor.

______b. An integrator circuit contains a series capacitor and a shunt resistor.

______c. In a differentiator, the output voltage is proportional to the time integral of the input voltage.

______d. In an integrator, the output voltage is proportional to the time integral of the input voltage.

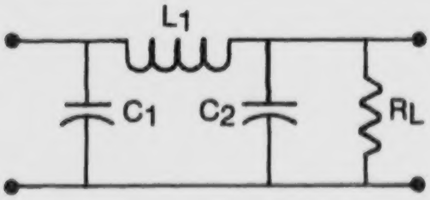
______e. A differentiator maintains a specific ratio of differentials.

______f. An integrator provides continuous adding capabilities.

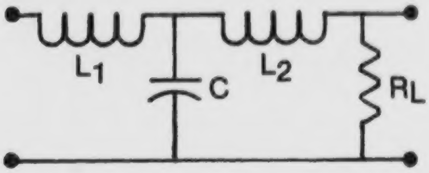
Written Test

50. Identify configurations of filter circuits.

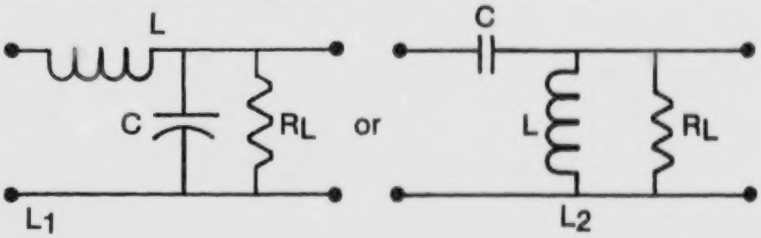
a. ______________________________



b. ______________________________



c. ______________________________



51. Match the operation of types of filter circuits to their correct descriptions. Write the corresponding numbers on the blanks provided.

______a. Reduces the voltage or current ripple by providing storage for part of the charge

______b. Uses an inductor to oppose changes in current, thus reducing ripple

______c. Prevents bandwidths of certain undesired frequencies from going through the circuit

______d. Allows only bandwidths of certain desired frequencies to go through the circuit

______e. Routes signals of certain bandwidths around a circuit or section of a circuit

1. Band-pass filter
2. Band-stop filter
3. By-pass filter
4. Capacitive filter
5. Choke filter

Written Test

52. Distinguish between the operation of a high-pass filter and a low-pass filter. Write an "H" beside the statement below that describes a high-pass filter and an "L" beside the statement that describes a low-pass filter.

______a. Uses bypass capacitance in parallel with the load and choke inductance in series with the load

______b. Uses coupling capacitance in series with the load and choke inductance in parallel with the load

53. State guidelines for impedance matching.

a. Best efficiency--____

____

b. Method for matching—____

____

54. Complete statements regarding rectangular notation.

a. Uses the letter *j* to indicate the direction of ______________ (clockwise or counterclockwise) of a vector.

b. A +j indicates the rotation of a vector in a ______________ direction through an angle of 90°.

c. A -j indicates the rotation of a vector in a ______________ direction through an angle of 90°.

d. A counterclockwise rotation indicates that the circuit has increasingly ______________ characteristics.

e. A clockwise rotation indicates that the circuit has increasingly ______________ characteristics.

f. Rectangular notation can be converted to polar notation by vector ______________ of rectangular components.

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Written Test

55. Complete statements regarding polar notation.

  a. Uses a numeric representation of the _______________ enclosed in an angle symbol, ∠.

  b. A +∠ indicates the rotation of a vector in a _______________ direction.

  c. A -∠ indicates the rotation of a vector in a _______________ direction.

  d. A counterclockwise rotation indicates that the circuit has increasingly _______________ characteristics.

  e. A clockwise rotation indicates that the circuit has increasingly _______________ characteristics.

  f. Polar notation can be converted to rectangular notation through _______________ conversion and the use of the formula Z = Z cosine ±jZ sine.

*Permission to duplicate this test is granted.

AC and AC Circuits
Unit 5

Unit Evaluation Form

Student Name ______________________________ Unit Rating ____________

Assignment Sheet Ratings

Assignment Sheet 1—Determine Sine Wave Conversions Rating _____

Comments: ____

____

Assignment Sheet 2—Compute Period Rating _____

Comments: ____

____

Assignment Sheet 3—Determine Current Flow Direction Rating _____

Comments: ____

____

Assignment Sheet 4—Solve for Total Inductance Rating _____

Comments: ____

____

Assignment Sheet 5—Compute Inductive Reactance Rating _____

Comments: ____

____

Assignment Sheet 6—Compute Applied Voltage and Impedance of RL Circuits Rating _____

Comments: ____

____

Unit Evaluation Form

Assignment Sheet 7—Compute Inductor Quality Rating _____

Comments: ______________________________

____

Assignment Sheet 8—Solve Time Constant Problems Rating _____

Comments: ______________________________

____

Assignment Sheet 9—Compute Capacitance Values Rating _____

Comments: ______________________________

____

Assignment Sheet 10—Compute RC Time Constants Rating _____

Comments: ______________________________

____

Assignment Sheet 11—Compute Capacitive Reactance Rating _____

Comments: ______________________________

____

Assignment Sheet 12—Determine Phase Relationships in RC Circuits Rating _____

Comments: ______________________________

____

Assignment Sheet 13—Calculate Values of RC Circuits Rating _____

Comments: ______________________________

____

Unit Evaluation Form

Assignment Sheet 14—Solve for Reactance Rating _____

Comments: ____

____

Assignment Sheet 15—Solve for Impedance Rating _____

Comments: ____

____

Assignment Sheet 16—Solve for Parameters of Resonant Circuits Rating _____

Comments: ____

____

Assignment Sheet 17—Solve Problems Related to Parallel RCL Circuits Rating _____

Comments: ____

____

Assignment Sheet 18—Analyze a Parallel Resonant Circuit Rating _____

Comments: ____

____

Assignment Sheet 19—Calculate the Power in Three-Phase Circuits Rating _____

Comments: ____

____

Assignment Sheet 20—Determine Three-Phase Transformer Connections Rating _____

Comments: ____

____

Unit Evaluation Form

Job Sheet Ratings

Job Sheet 1—Measure AC Voltages Using a Multimeter Rating _____

Comments: ____

____

Job Sheet 2—Measure AC Current Using a Multimeter Rating _____

Comments: ____

____

Job Sheet 3—Determine the Configuration of a Multiple-Winding Transformer Rating _____

Comments: ____

____

Job Sheet 4—Test and Replace a Transformer Rating _____

Comments: ____

____

Job Sheet 5—Show the Effect of Inductance in AC Circuits Rating _____

Comments: ____

____

Job Sheet 6—Solve for Values of an Operating RL Circuit Rating _____

Comments: ____

____

Job Sheet 7—Test Capacitors with an Ohmmeter Rating _____

Comments: ____

____

Unit Evaluation Form

Job Sheet 8—Determine the Effect of AC and DC on Capacitors Rating _____

Comments: ____

____

Job Sheet 9—Determine Time Constants of RC Circuits Rating _____

Comments: ____

____

Job Sheet 10—Construct a Neon Bulb Flasher Rating _____

Comments: ____

____

Job Sheet 11—Show the Effect of Capacitive Reactance in AC Circuits Rating _____

Comments: ____

____

Job Sheet 12—Determine Capacitive Reactance and Impedance in RC Circuits Rating _____

Comments: ____

____

Job Sheet 13—Determine Resonance in a Series RCL Circuit Rating _____

Comments: ____

____

Job Sheet 14—Determine the Resonant Frequency of an RCL Parallel Circuit Rating _____

Comments: ____

____

Unit Evaluation Form

Job Sheet 15—Troubleshoot AC Circuits Rating _____

Comments: ____

____

Written-Test Scores

Pretest _______ Posttest _______ Other _______

Other ____

____

Teacher Signature ______________________________ Date ______________

Student Signature ______________________________ Date ______________

***Permission to duplicate this form is granted.**

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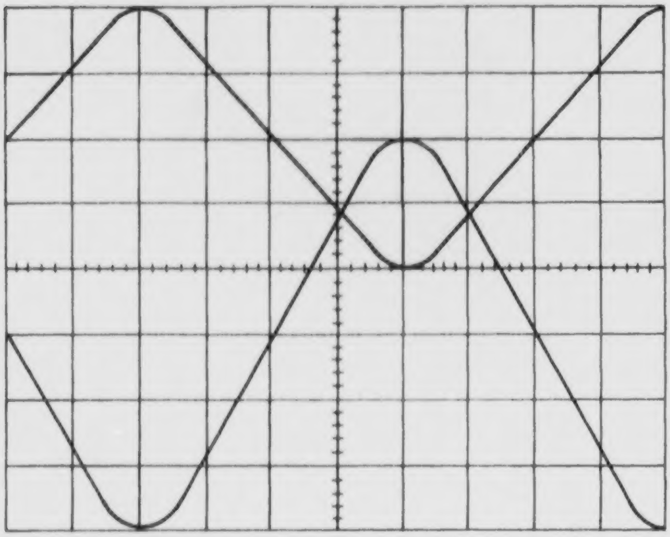
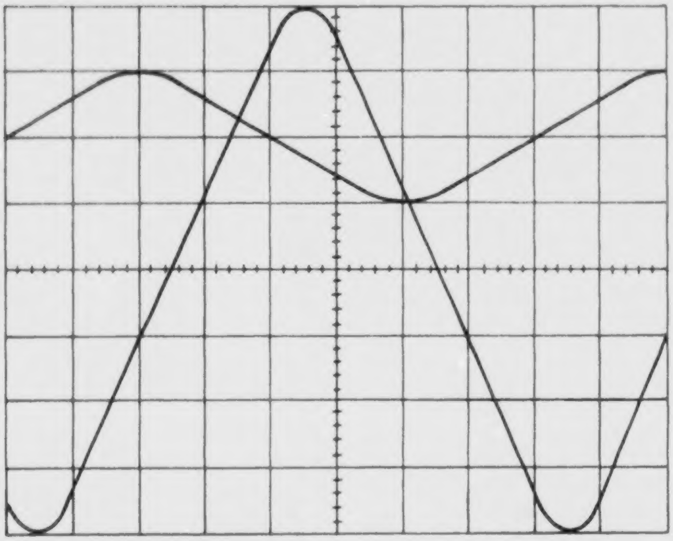
Sine Wave Relationships

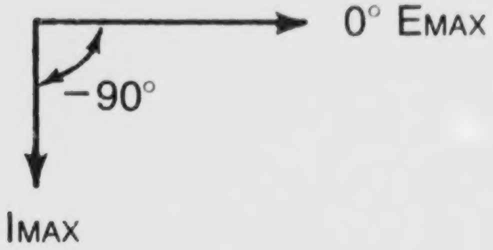


1 Cycle = 8 cm
1 cm = 45°
4 cm between Peaks
4 cm x 45° = 180°
or 180° Out of Phase

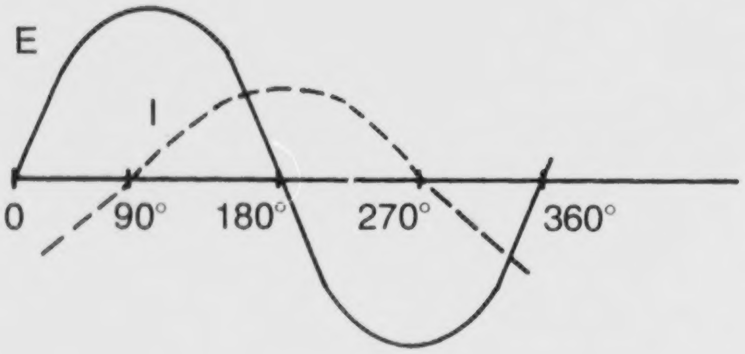


2.6 cm x 45° = 117°
or 117° Out of Phase

Comparison of Sinusoidal and Phasor (Vector) Diagrams

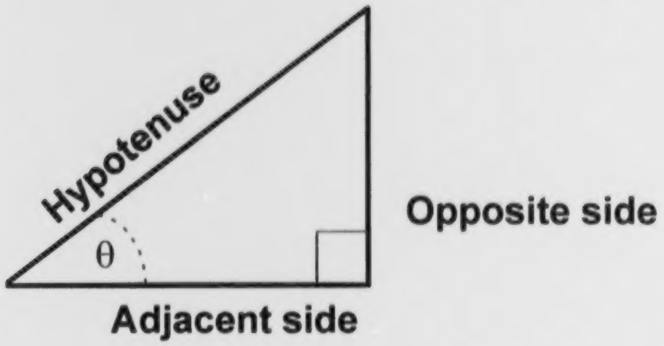


Phasor Diagram
(Vector Diagram)



Sinusoidal Graph

Trigonometric Functions



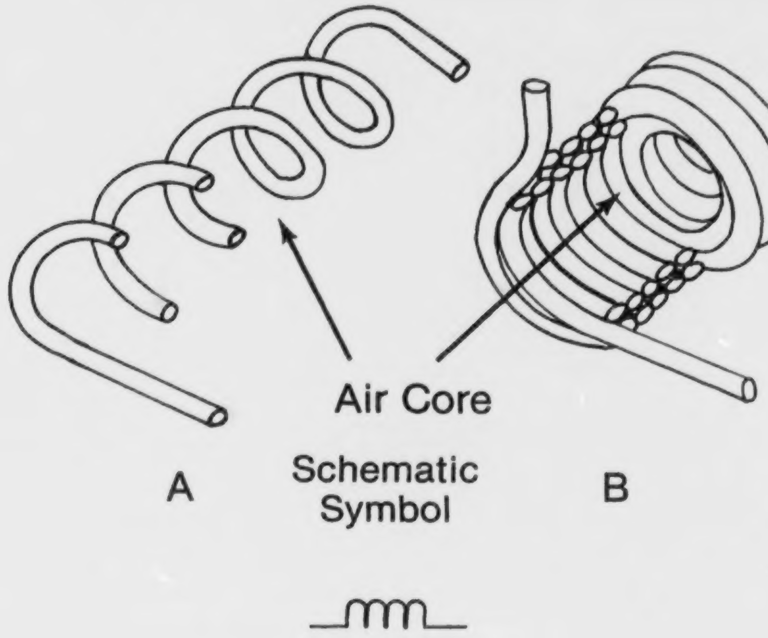
$$\text{Sine of theta } (\sin\theta) = \frac{\text{Opposite side}}{\text{Hypotenuse}}$$

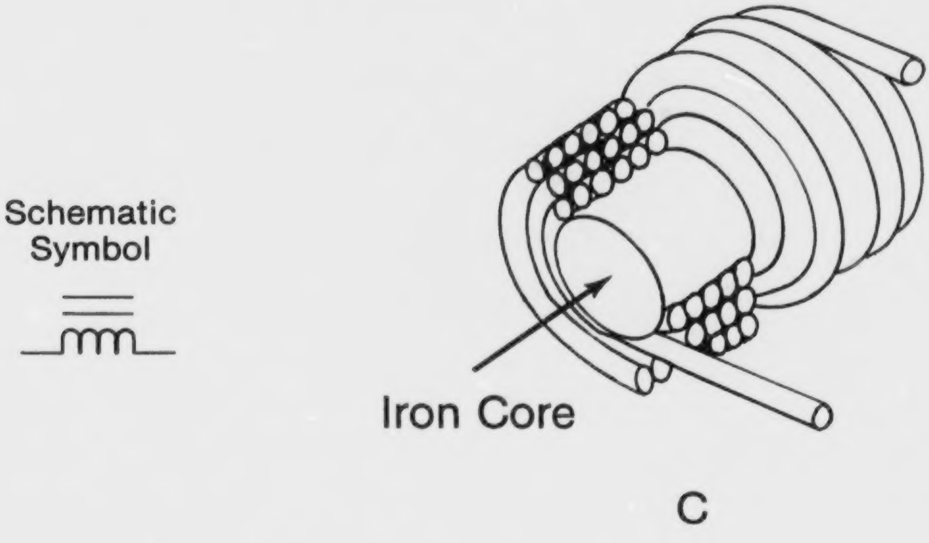
$$\text{Cosine of theta } (\cos\theta) = \frac{\text{Adjacent side}}{\text{Hypotenuse}}$$

$$\text{Tangent of theta } (\tan\theta) = \frac{\text{Opposite side}}{\text{Adjacent side}}$$

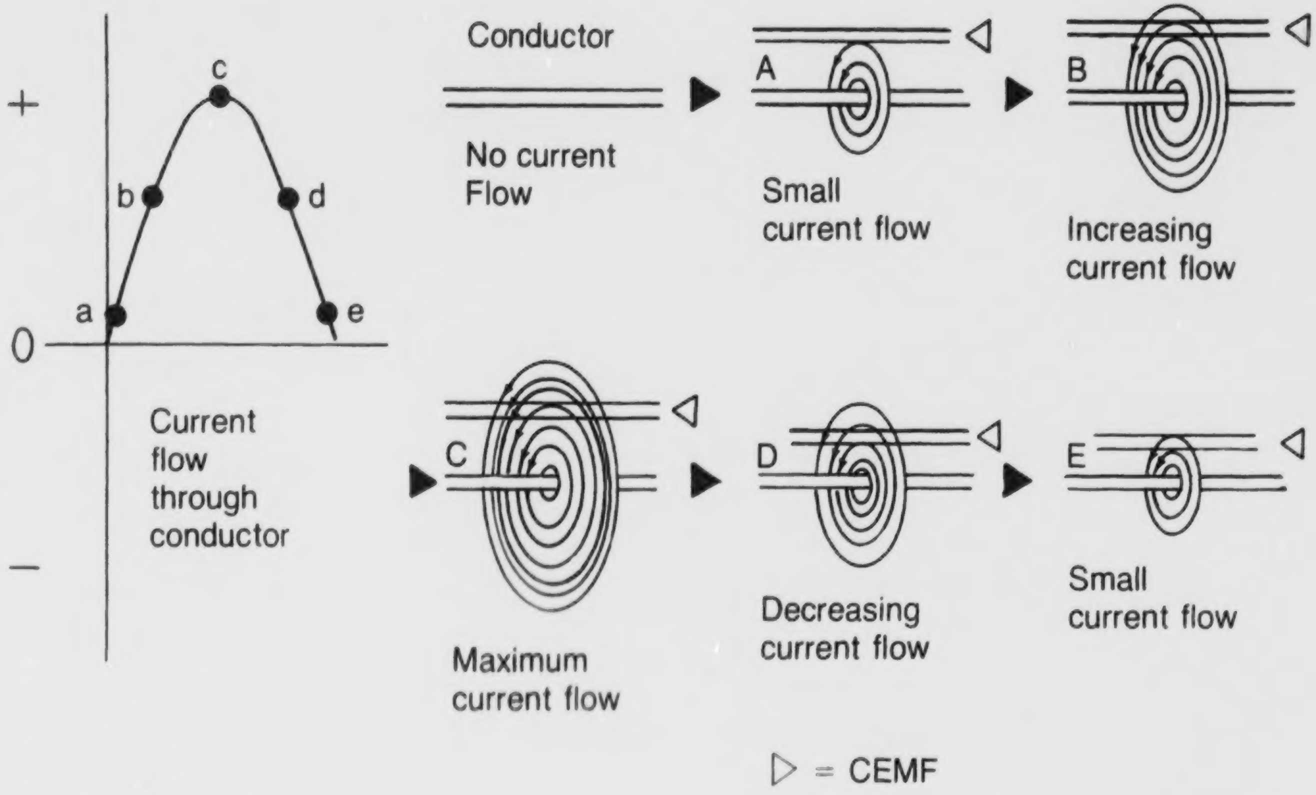
These trigonometric functions describe the relationships among the three sides of a right triangle. These calculations can be used with trigonometric tables or some calculators to determine unknown angles when the lengths of the sides are known or the values of vectors.

Coils of Various Inductances


Air Core
A
Schematic
Symbol
B

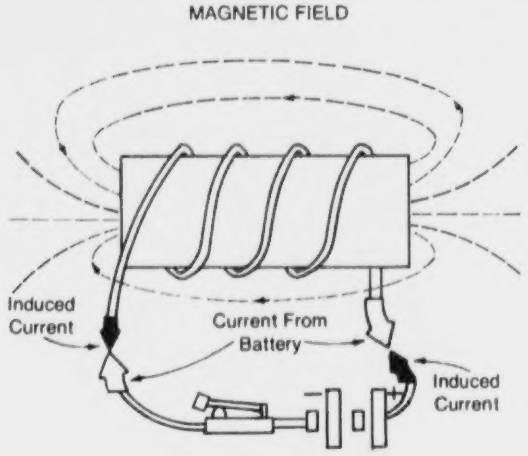

Schematic
Symbol
Iron Core
C

Induction

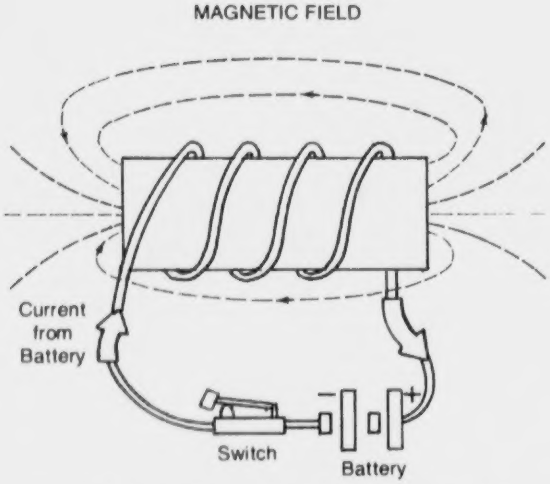

+
0
−
a
b
c
d
e
Current flow through conductor
Conductor
No current Flow
A
Small current flow
B
Increasing current flow
C
Maximum current flow
D
Decreasing current flow
E
Small current flow
▷ = CEMF

Relationship of magnetic field around a wire to current flowing through the wire.

Self-Induction in a Coil

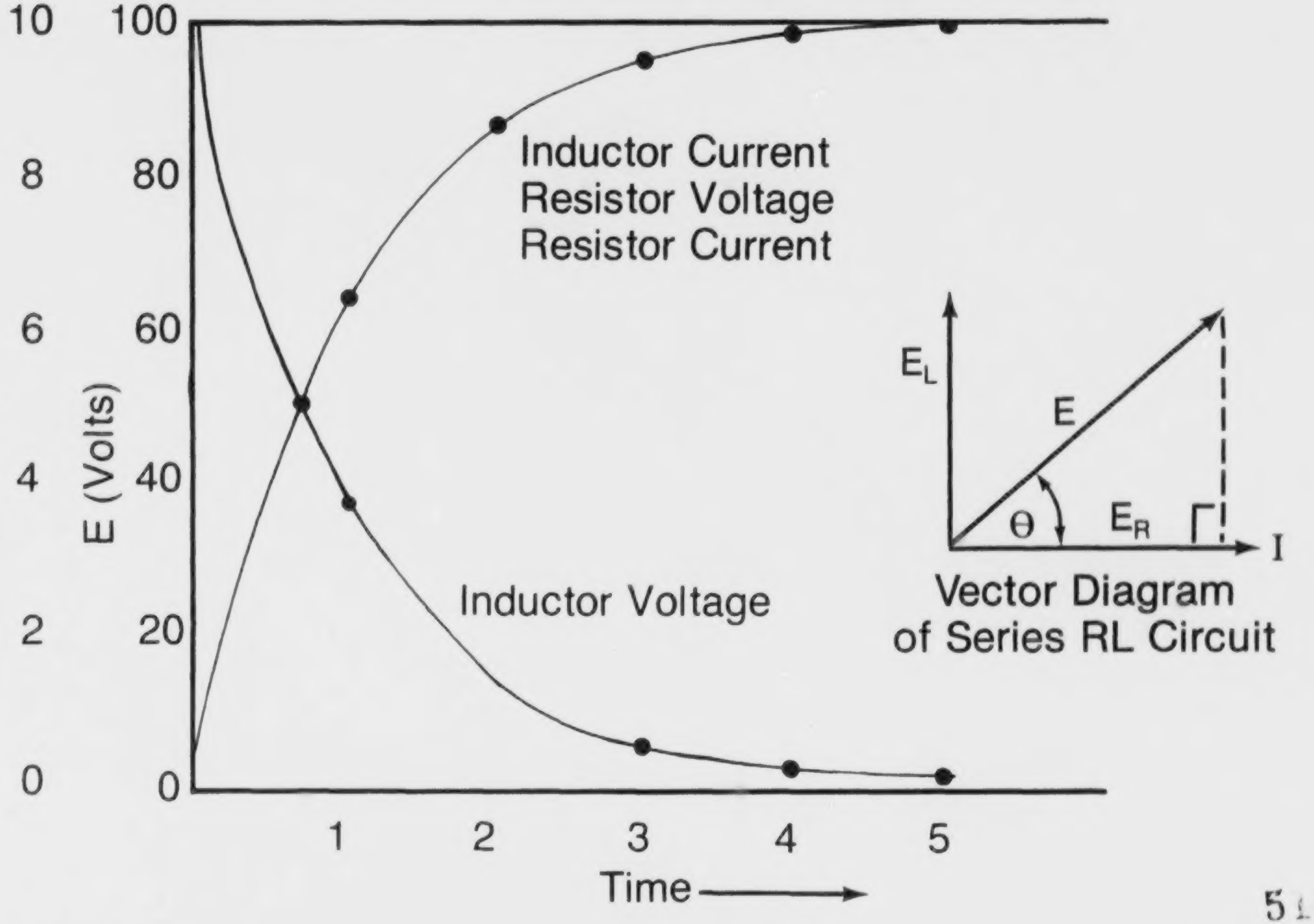

MAGNETIC FIELD
Induced Current
Current From Battery
Induced Current
−
+

A. Current Creates
Magnetic Field

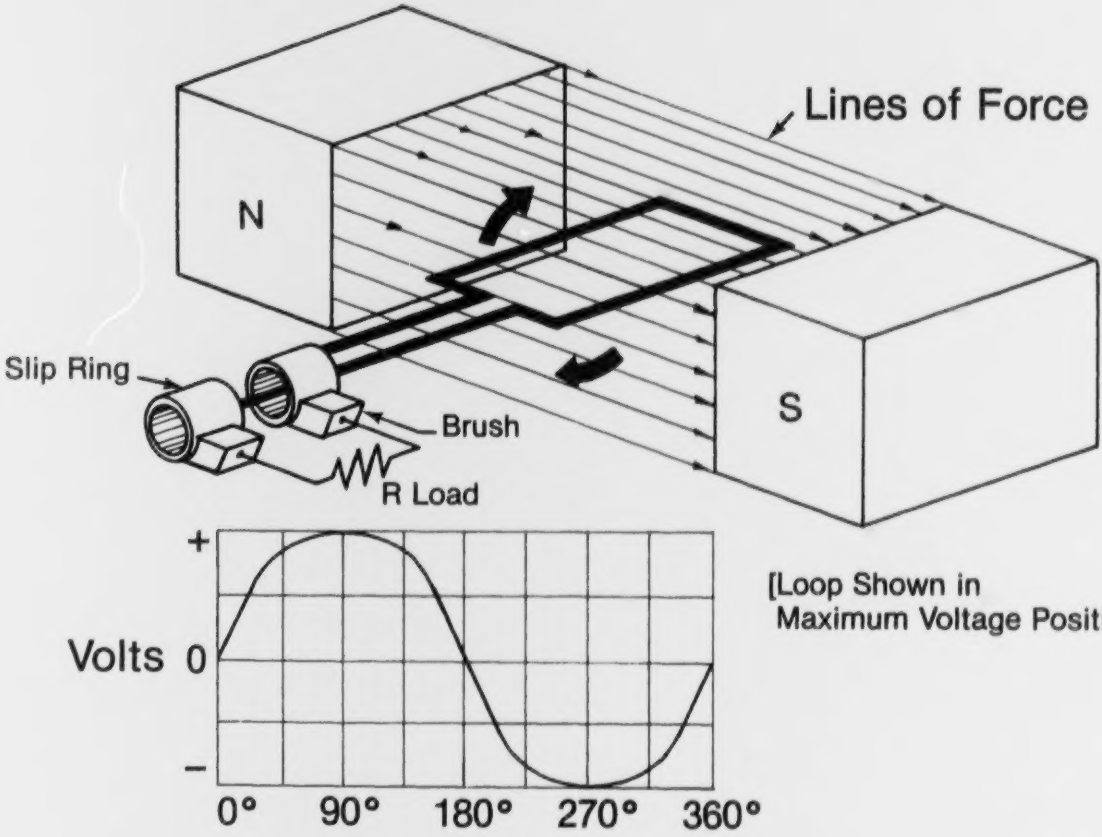

MAGNETIC FIELD
Current from Battery
−
+
Switch
Battery

B. Magnetic Field Induces
Opposing Current

Current and Voltage in an RL Circuit



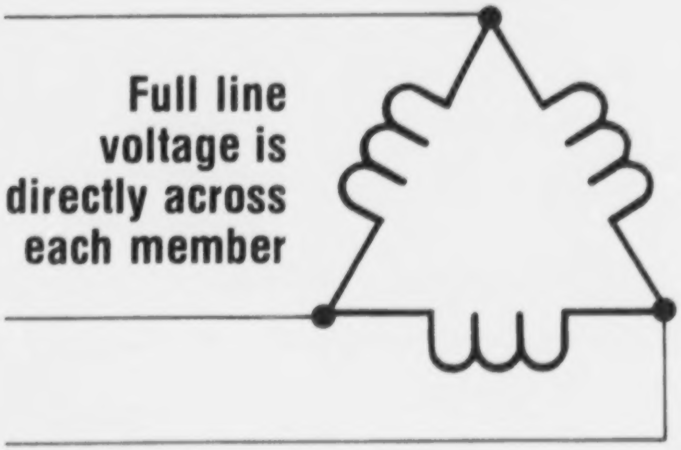
Simple AC Generator


Lines of Force
N
S
Slip Ring
Brush
R Load
+
Volts 0
–
0°
90°
180°
270°
360°

[Loop Shown in Maximum Voltage Position]

Types of Three-Phase Circuits

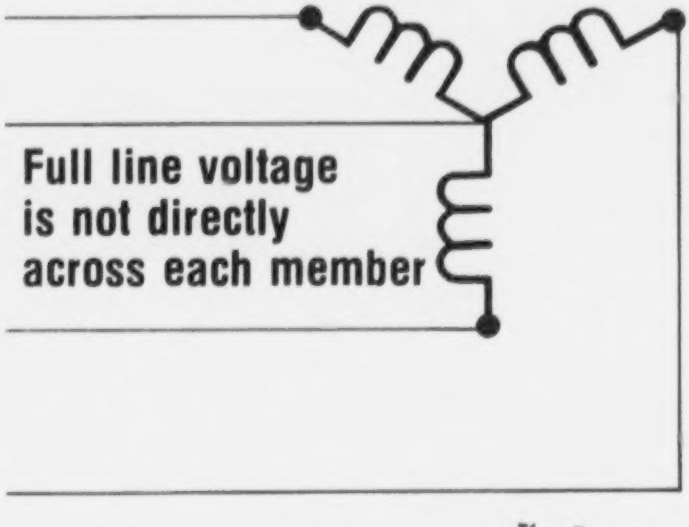
Delta



Full line voltage is directly across each member

Full-line amperage is not through each member

Wye



Full-line current is through each member

Full line voltage is not directly across each member

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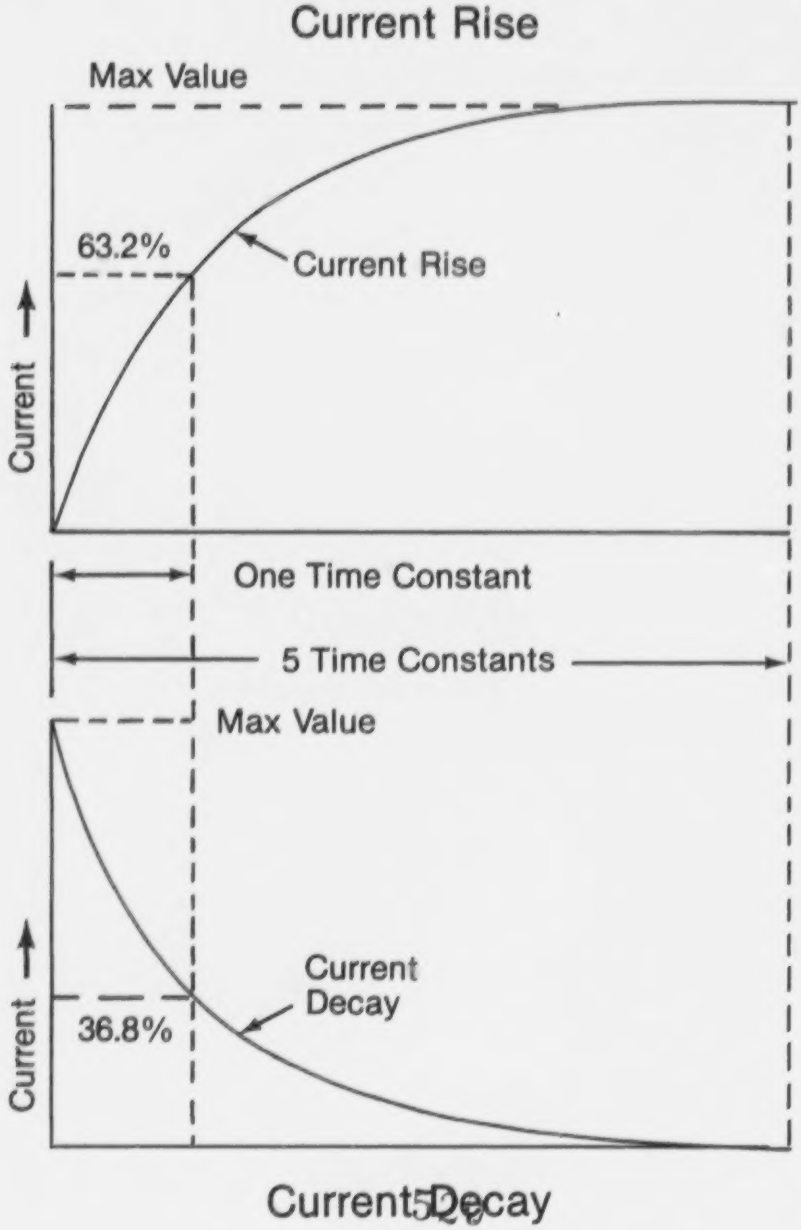
Current Rise and Fall in an Inductor



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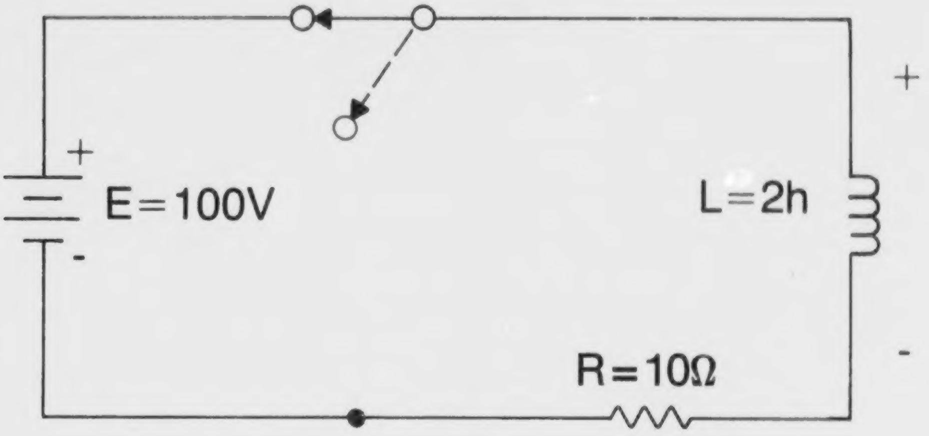
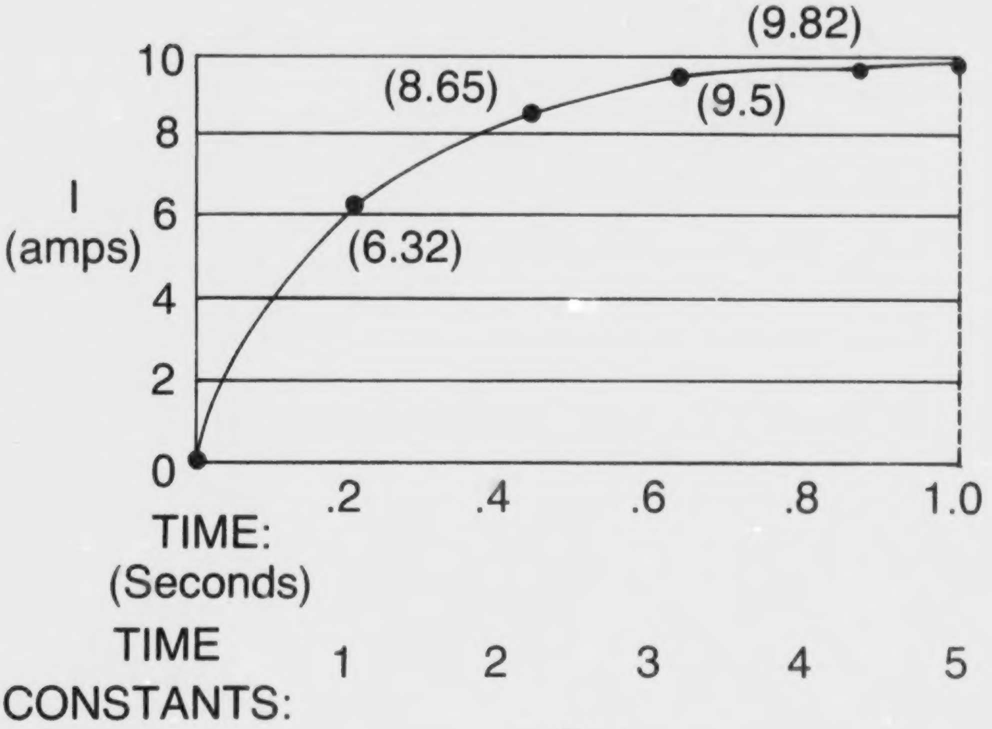
RL Circuit and Current Rise

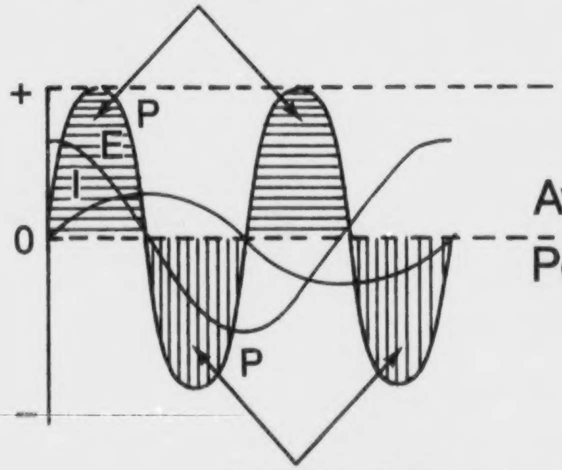


+
E=100V
-
L=2h
+
-
R=10Ω



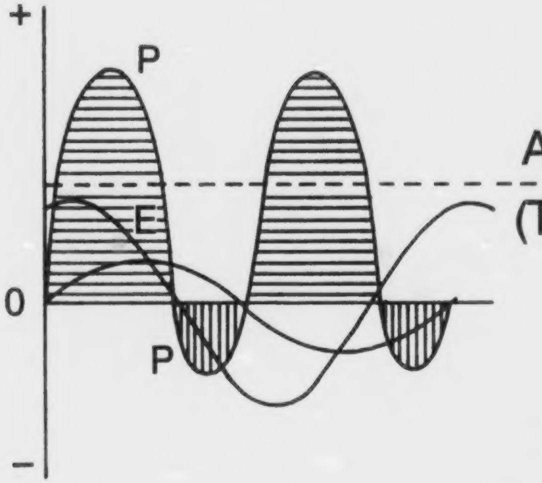
Power in RL Circuits

Power Consumed by the Inductor



Average Power - Zero

Power Returned to the Circuit by the Inductor



Average (True) Power

Capacitor Construction

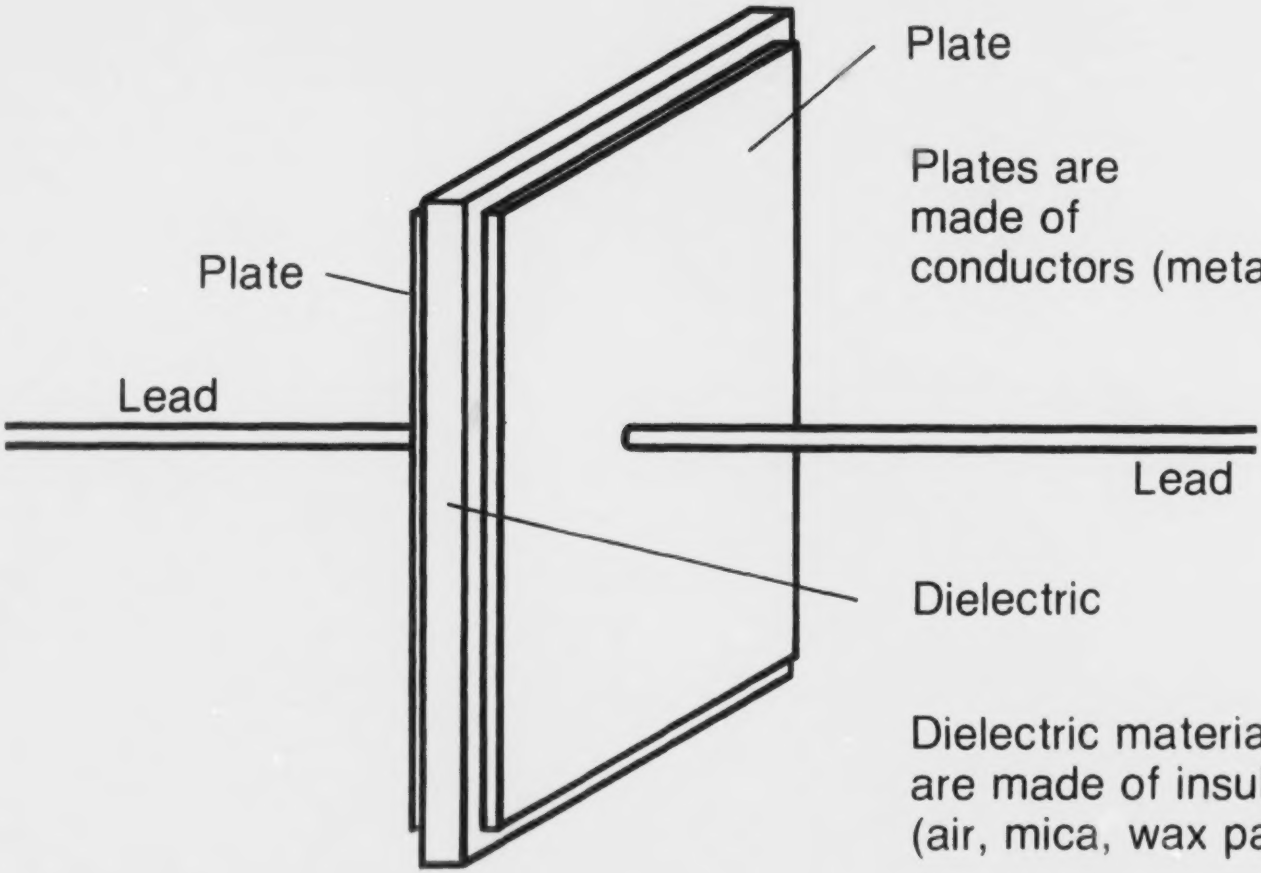
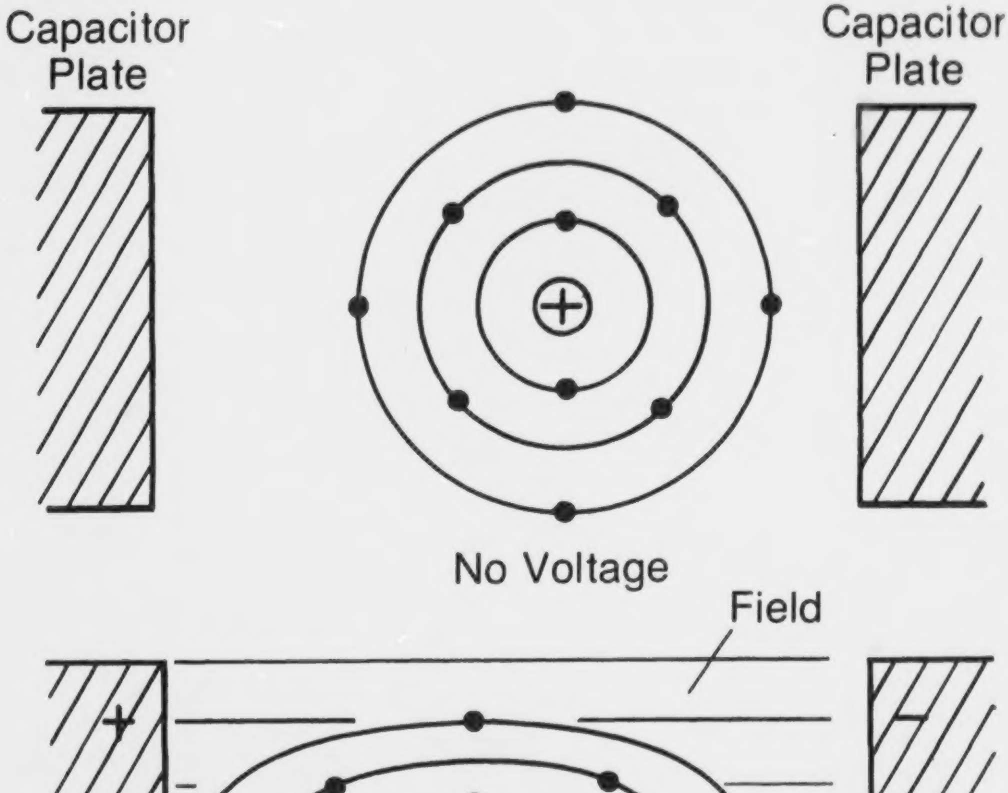


Plate
Plate
Lead
Lead
Dielectric

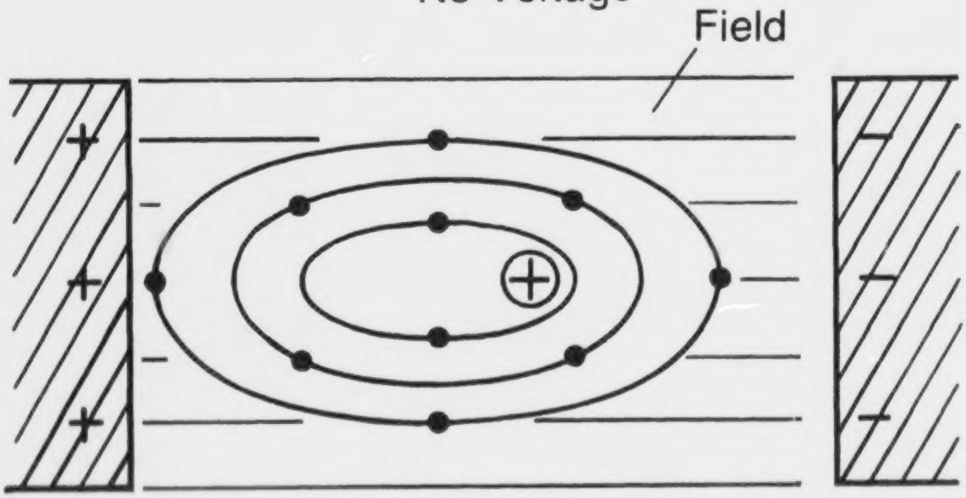
Plates are
made of
conductors (metals)

Dielectric materials
are made of insulators
(air, mica, wax paper)

Electric Field Effect on Dielectrics

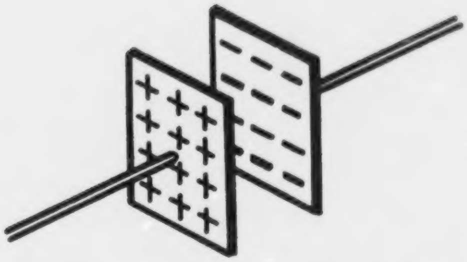

Capacitor Plate
Capacitor Plate
+

No Voltage

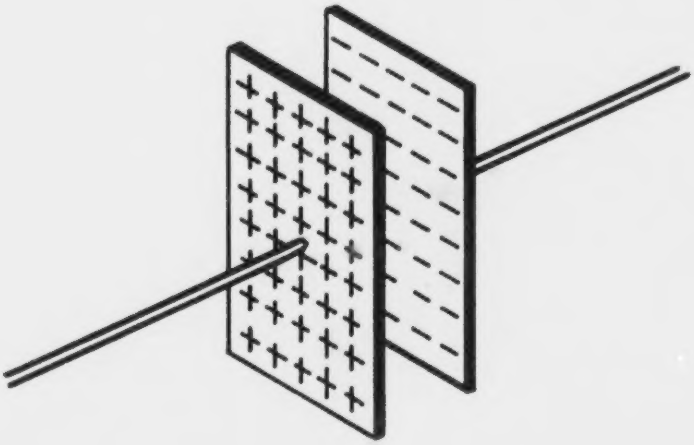


Voltage Applied

Plate Area

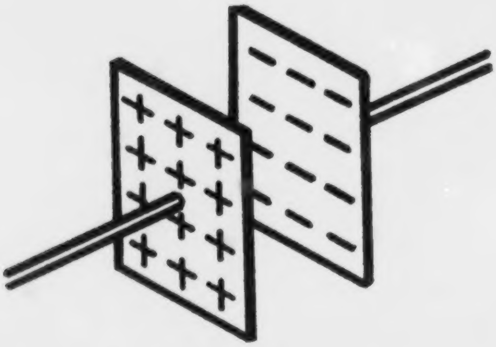


Larger plates hold more electrons.

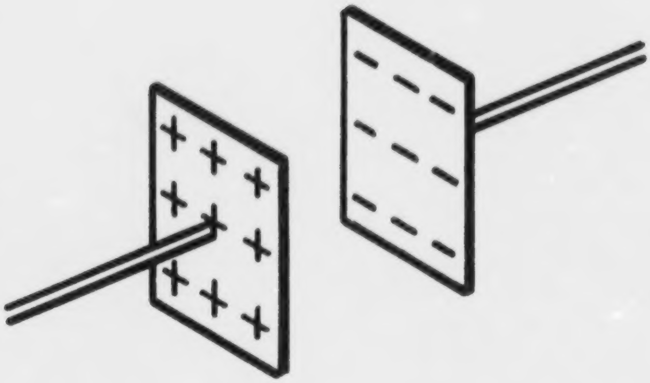


Increased plate area increases capacitance.

Plate Distance

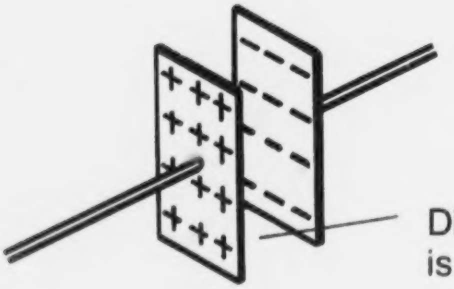


The distance between two charges determines their effect on one another.

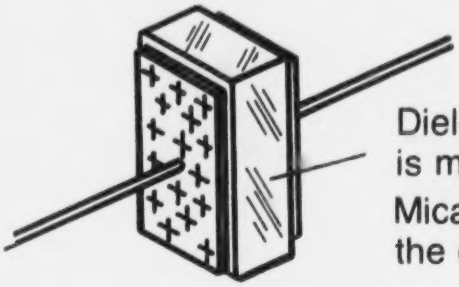


Increasing the distance between the plates decreases capacitance.

Effect of the Dielectric



Dielectrical material
is air.



Dielectrical material
is mica.
Mica dielectric increases
the capacitance.

Changing the dielectric material changes the capacitance.

Dielectric Strength of Common Insulators

Material	Dielectric Strength (V/mil)
Air or vacuum	20
Bakelite™	300-550
Fiber	150-180
Glass	335-2,000
Mica	600-1,500
Paper	1,250
Paraffin oil	380
Paraffin wax	200-300
Phenol (molded)	300-700
Polystyrene	500-760
Porcelain	40-150
Rubber (hard)	450
Shellac	900

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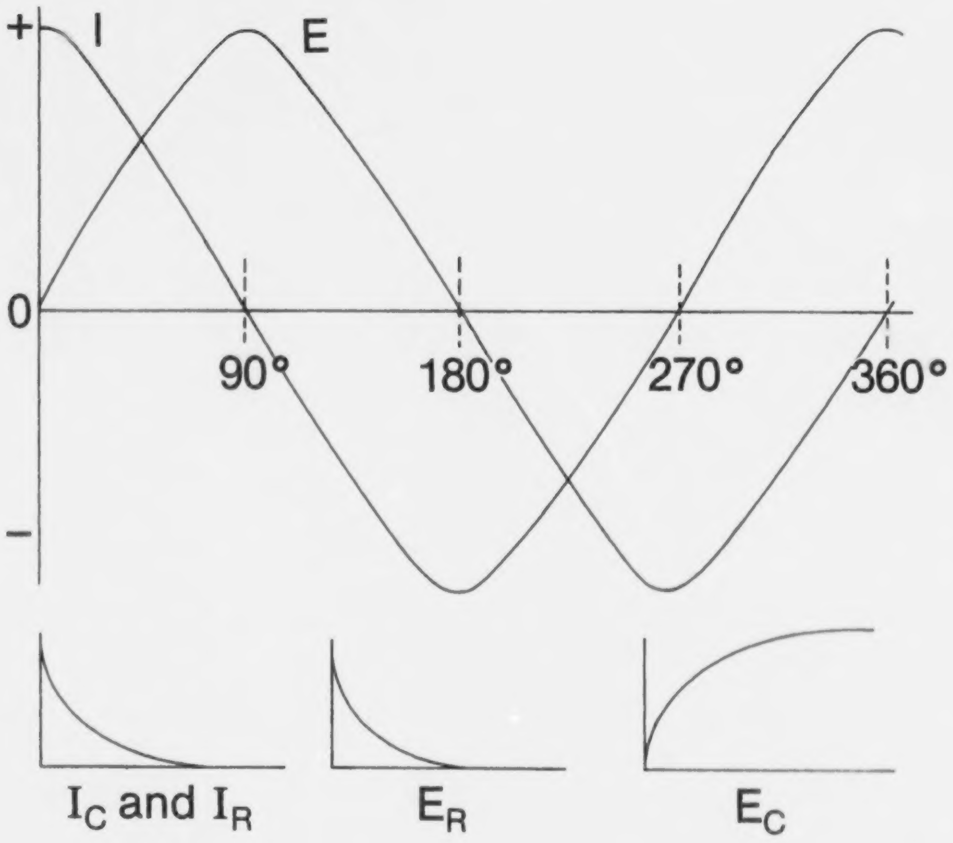
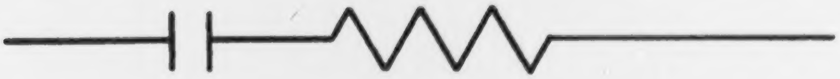
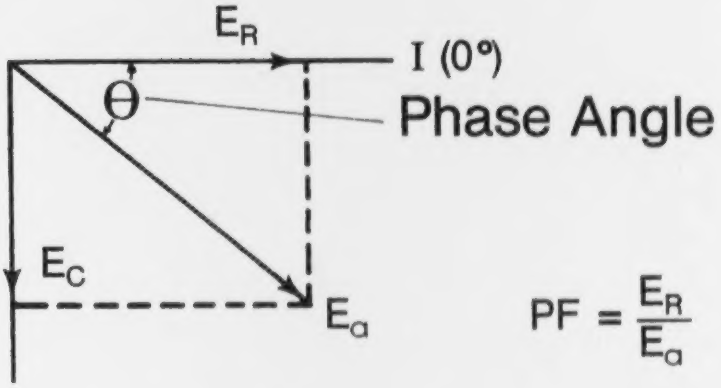
Current and Voltage Relationships in RC Circuits



Voltage in RC Circuits

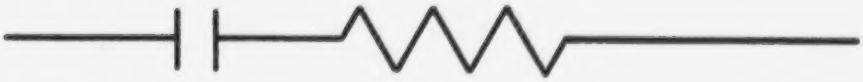


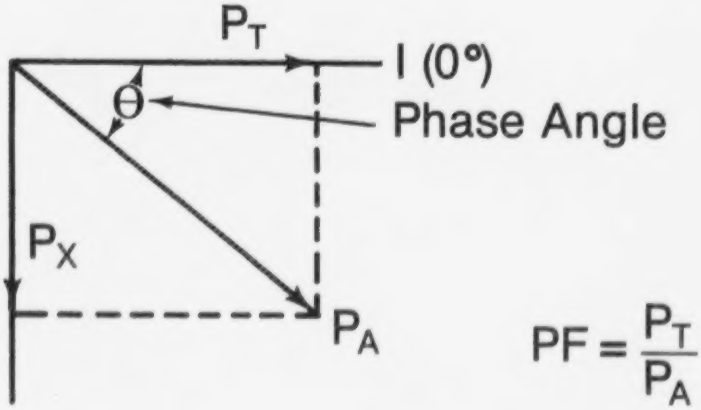

E_R
I (0°)
θ
Phase Angle
E_C
E_a

$$PF = \frac{E_R}{E_a}$$

$$E_a = I \times Z = \sqrt{(E_a)^2 + (E_R)^2}$$

Power in RC Circuits

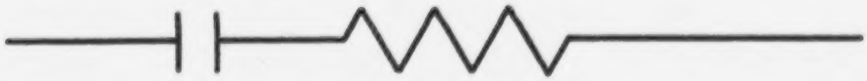


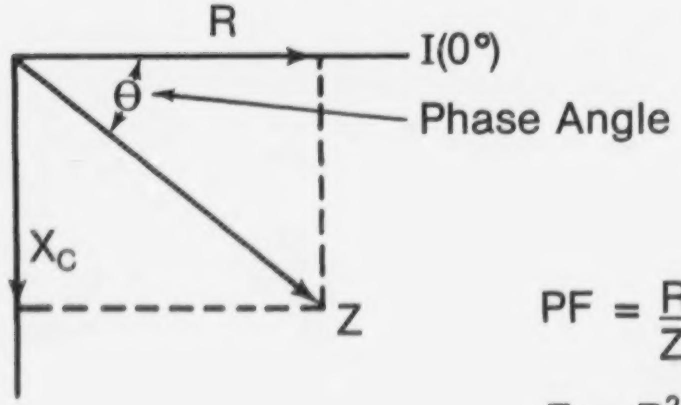

P_T
I (0°)
θ
Phase Angle
P_X
P_A

$$PF = \frac{P_T}{P_A}$$

$$P_A = E_A \times I$$

Impedance in RC Circuits

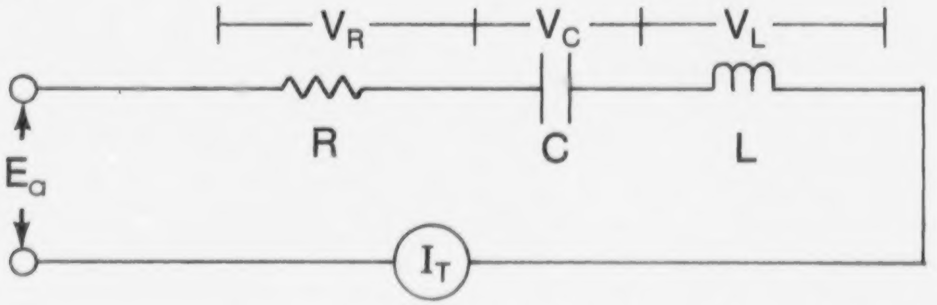



R
I(0°)
θ
Phase Angle
X_C
Z

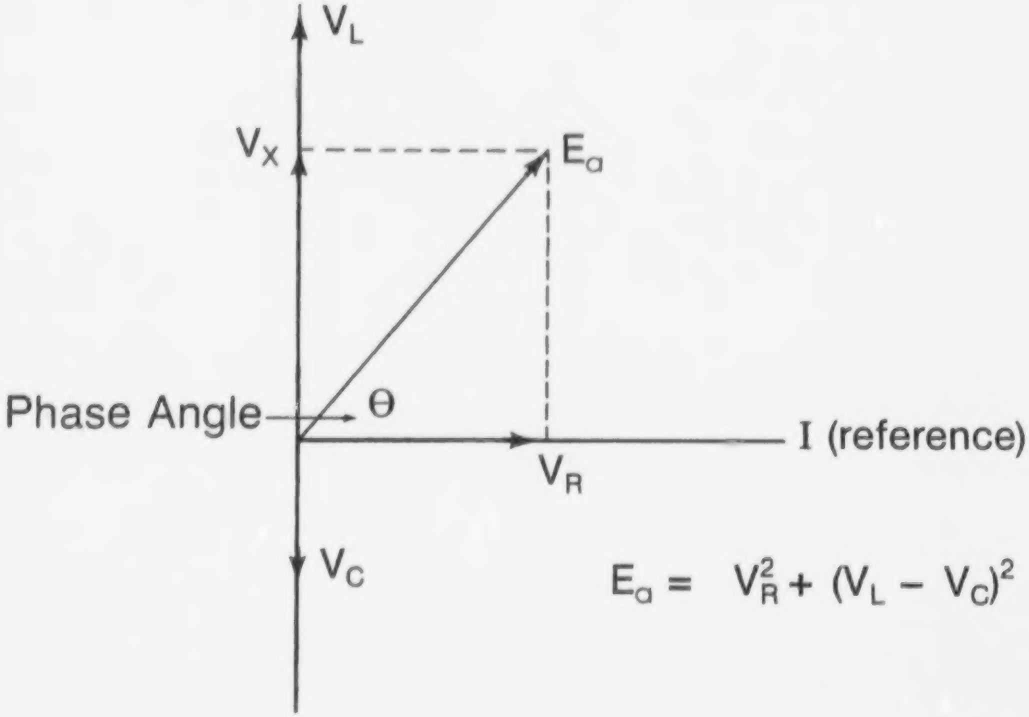
$$PF = \frac{R}{Z}$$

$$Z = R^2 + X_C^2$$

Voltage Relationship in a Series RCL Circuit


V_R
V_C
V_L
R
C
L
E_a
I_T

I_T $\quad I_T = I_R = I_C = I_L$


V_L
V_X
E_a
Phase Angle
Θ
I (reference)
V_R
V_C

$$E_a = \; V_R^2 + (V_L - V_C)^2$$

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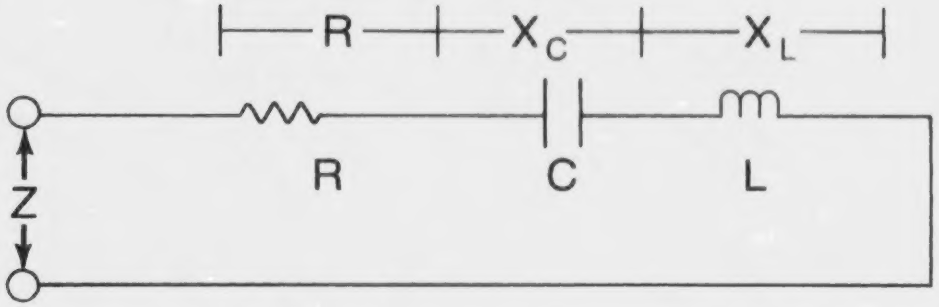
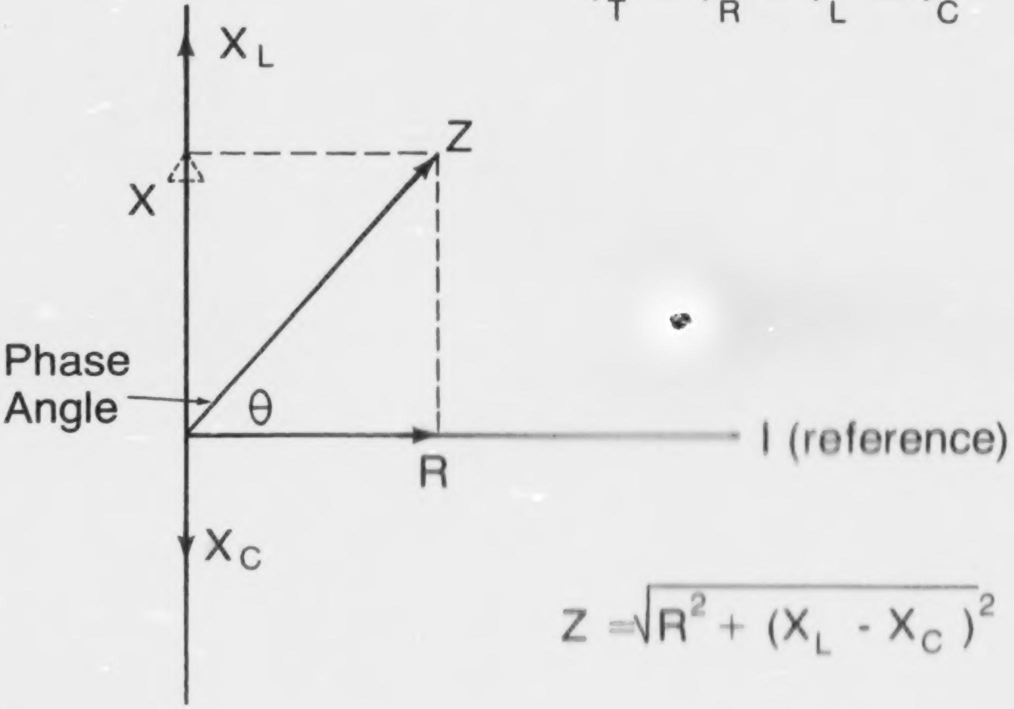
Impedance Relationship in a Series RCL Circuit

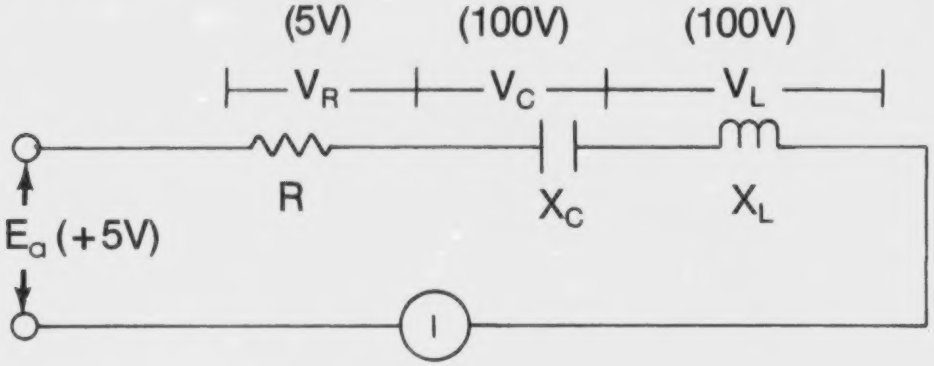


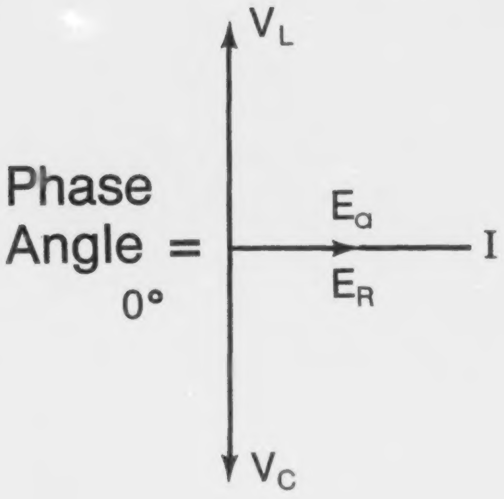
$$I_T = I_R = I_L = I_C$$

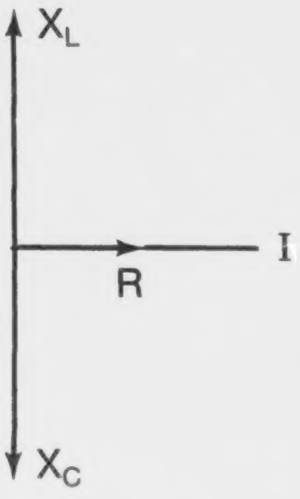

X_L
Z
X
Phase Angle
θ
R
I (reference)
X_C

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

Resonance Relationship in a Series RCL Circuit

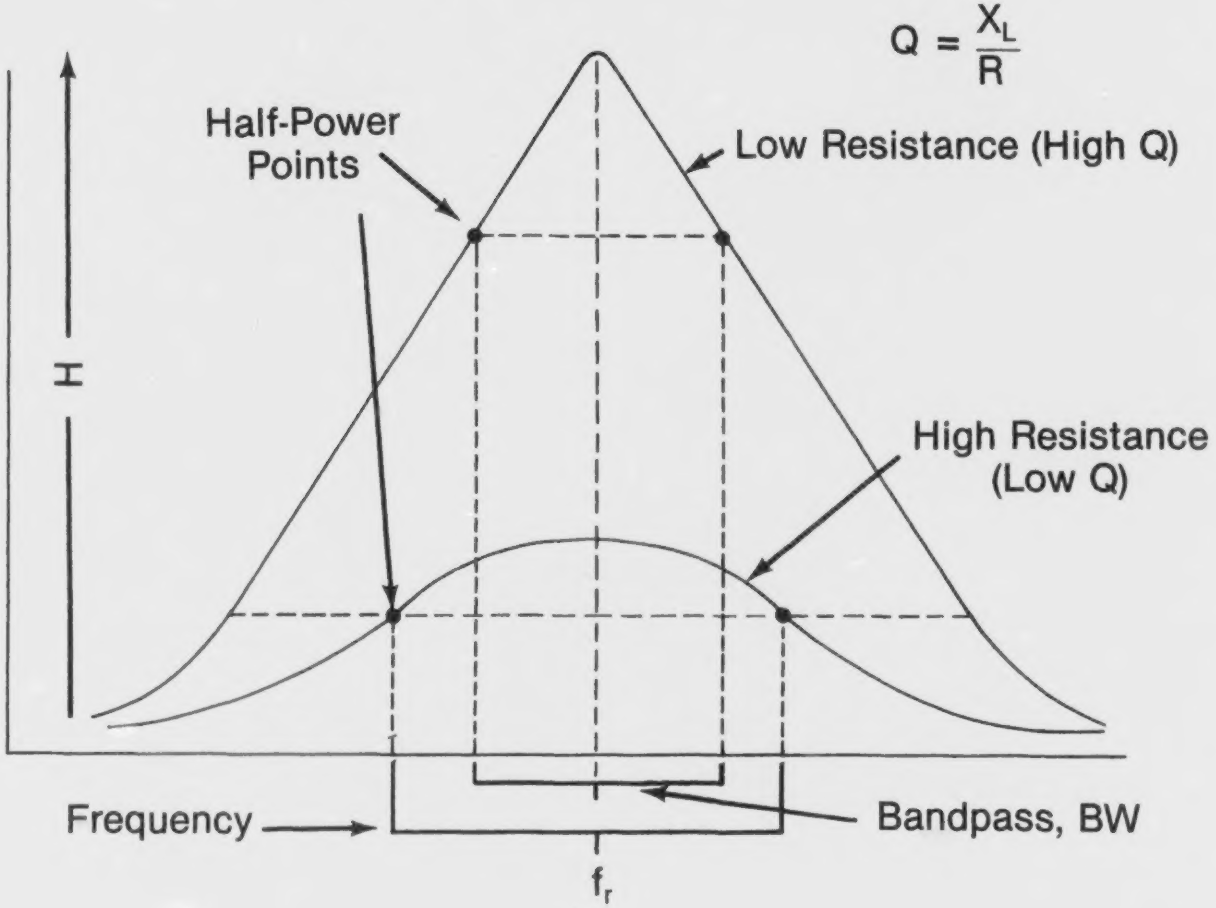

(5V)
(100V)
(100V)
V_R
V_C
V_L
R
X_C
X_L
E_a (+5V)
I


V_L
Phase Angle = 0°
E_a
I
E_R
V_C

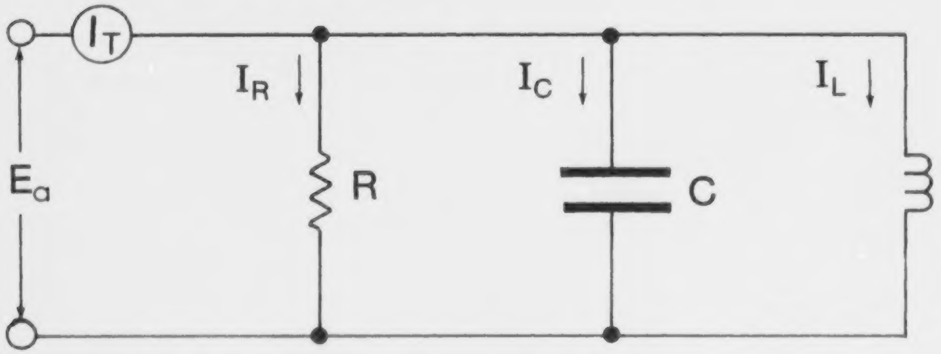


$E_L = E_C$; $E_a = E_R$ $\qquad$ $X_C = X_L$; $Z = R$

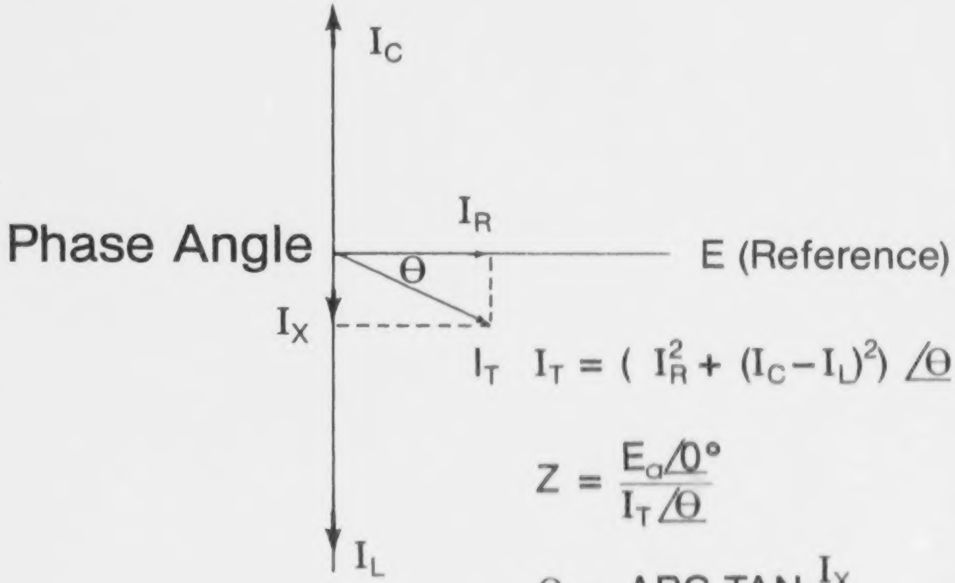
Typical Resonant Curves



Current Relationship in a Parallel RCL Circuit


I_T
I_R
I_C
I_L
E_a
R
C

$$E_a = V_R = V_C = V_L$$


I_C
I_R
Phase Angle
θ
E (Reference)
I_X
I_T
I_L

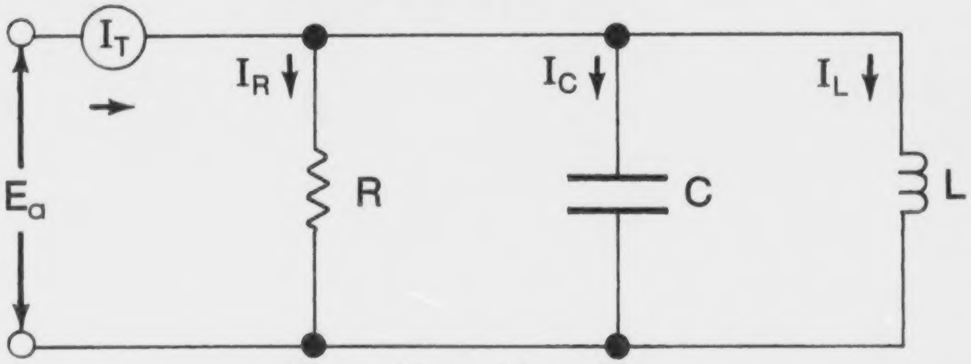
$$I_T = (\ I_R^2 + (I_C - I_L)^2)\ \angle\theta$$

$$Z = \frac{E_a \angle 0°}{I_T \angle \theta}$$

$$\theta = \text{ARC TAN}\ \frac{I_X}{I_R}$$

$$\theta = \text{ARC COS}\ \frac{I_R}{I_T}$$

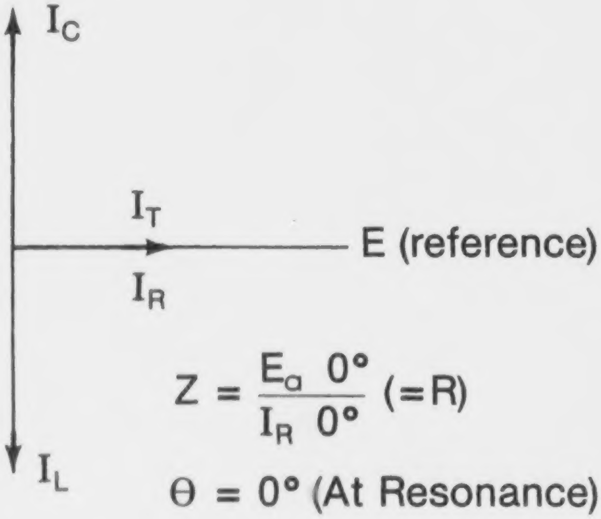
Resonance Relationship in a Parallel RCL Circuit



I_T
I_R
I_C
I_L
E_a
R
C
L

$E_a = V_R = V_C = V_L$

Phase Angle = 0°



I_C
I_T
I_R
E (reference)
I_L

$$Z = \frac{E_a \ 0°}{I_R \ 0°} \ (=R)$$

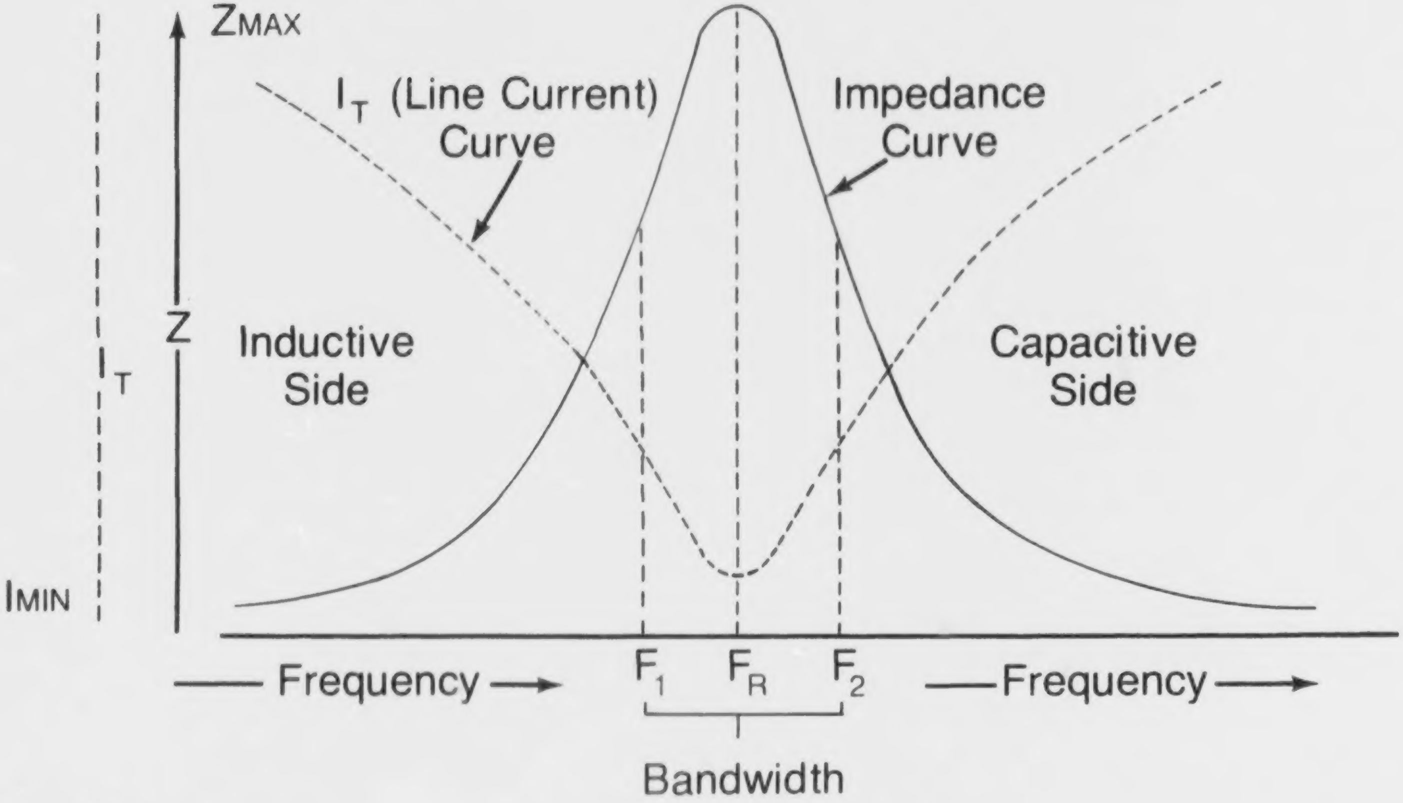
$\Theta = 0°$ (At Resonance)

$I_C = I_L$

$I_T = I_R$

$Z = R$

Tuned Parallel Circuit Curves


ZMAX
I_T (Line Current) Curve
Impedance Curve
Z
I_T
Inductive Side
Capacitive Side
IMIN
Frequency →
F_1
F_R
F_2
Frequency →
Bandwidth

General Electronics Technician: Basic Electronics, Unit 5
Teacher Page 117

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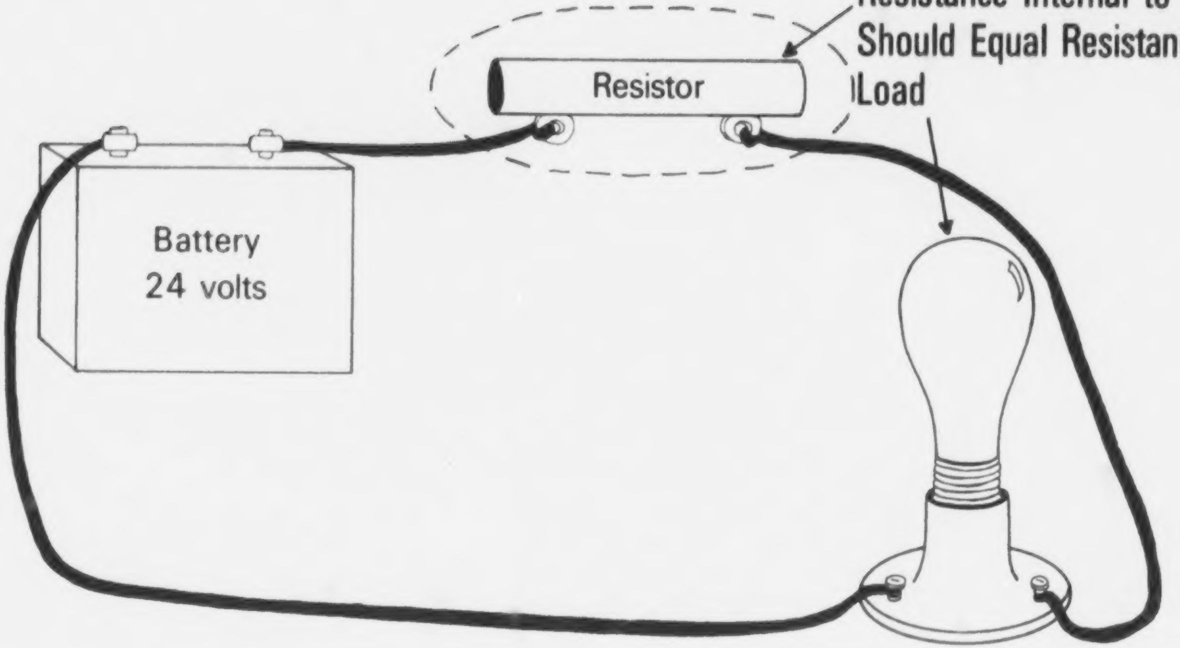
Impedance Matching


Resistor
Battery
24 volts

Resistance Internal to the Source Should Equal Resistance of the Load

General Electronics Technician: Basic Electronics

Student Edition

MAVCC

545

BEST COPY AVAILABLE

General Electronics Technician:

Basic Electronics

Student Edition

Written by

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Project coordinated by

Jane Huston, Curriculum Coordinator
Multistate Academic and Vocational Curriculum Consortium, Inc.

Project developed by

The Multistate Academic and Vocational Curriculum Consortium, Inc.
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General Electronics Technician:

Basic Electronics

Student Edition

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Introduction to Electricity and Electronics
Unit 1

Objective Sheet

Unit Objective

After completing this unit, the student should be able to discuss the electron theory of electricity and apply the theory and related laws to the electronics industry. The student should demonstrate these competencies by completing the assignment sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms associated with electricity and electronics to their correct definitions.
2. List the four areas of employment in the electronics industry.
3. Match different areas of scientific study in the electronics industry to their correct descriptions.
4. Complete statements concerning the electron theory of electricity.
5. Select true statements concerning the electrical characteristics of conductors, insulators, and semiconductors.
6. Match sources of electricity to their correct descriptions.
7. Match characteristics of electrical flow to their correct descriptions.
8. Complete a chart for units of measure, their abbreviations, and symbols for characteristics of electrical flow.
9. State Ohm's Law for calculating values of given characteristics of electrical flow.
10. State Watt's Law for calculating power.
11. Describe the two forms of electrical current.
12. Label the parts of a simple electrical circuit.
13. Match types of electrical circuit power sources to their correct descriptions.
14. State the purpose of the ground in an electrical circuit.
15. Describe types of grounds used with electronic equipment.
16. Match types of grounds used with electronic equipment to their correct symbols.
17. List classifications of electrical/electronic circuits.
18. Trace the flow of electricity in a series circuit.
19. Complete statements about electrical characteristics in a series circuit.

Objective Sheet

20. Trace the flow of electricity in a parallel circuit.
21. Complete statements about electrical characteristics in a parallel circuit.
22. Trace the flow of electricity in a series-parallel circuit.
23. Complete statements about electrical characteristics in a series-parallel circuit.
24. State Kirchhoff's first law regarding current in a circuit.
25. State Kirchhoff's second law regarding voltage in a circuit.
26. Complete statements about the principle of maximum power transfer.
27. State the Superposition Theorem.
28. State Thévenin's Theorem.
29. Match electrical components commonly used in electronic equipment to their correct descriptions.
30. Match electrical components commonly used in electronic equipment to their correct symbols.
31. Describe the difference in purposes between electrical circuits and electronic circuits.
32. List types of information that can be represented by electronic signals.
33. Describe the two types of electronic signals.
34. List the three categories of electronic devices.
35. Describe the four main functions of electronic devices.
36. Match electronic devices to their correct functions.
37. Match electronic devices to their correct symbols.
38. Match magnetic properties to their correct descriptions.
39. Classify substances based on their magnetic characteristics.
40. List ways of classifying magnets.
41. Complete statements about magnetic flux lines.
42. Complete statements about electromagnetism.
43. Describe induction.
44. List factors that influence the amount of current produced through induction.

Objective Sheet

45. State prefixes and symbols used with electrical and electronic terms to show decimal and powers of ten values.

46. Apply Ohm's Law. (Assignment Sheet 1)

47. Apply Watt's Law. (Assignment Sheet 2)

48. Trace current flow in electrical circuits. (Assignment Sheet 3)

49. Apply Kirchhoff's Laws. (Assignment Sheet 4)

50. Apply the superposition theorem. (Assignment Sheet 5)

51. Apply Thévenin's theorem. (Assignment Sheet 6)

52. Convert electrical units of measure. (Assignment Sheet 7)

53. Interpret electrical schematics. (Assignment Sheet 8)

Introduction to Electricity and Electronics
Unit 1

Information Sheet

1. **Terms and definitions**

   a. **Circuit**—Collection of conductors and devices designed to allow the controlled flow of electricity in order to perform work

   b. **Component**—Part of a circuit designed to serve a specific purpose in the circuit

   c. **Electron**—Particle thought to be found in all matter as part of the atom and to be the means by which electrical energy is generated

   d. **Electronics**—Branch of physics that deals with the use of electricity and special devices to generate, control, distribute, and interpret signals to operate equipment or communicate information

   e. **Energy**—The capacity to do work

   Note: Energy is what enables us to perform work. Energy comes in many forms: heat, radiation, light, nuclear, etc. One of the most important and the form of energy that is dealt with most in this course is electrical energy.

   f. **Equivalent**—Having the same value, effect, or function

   g. **Law**—Statement of a scientific principle that can be demonstrated

   h. **Matter**—That which has weight and occupies space

   Note: Matter includes all that you can see and touch—everything that has substance. Matter also possesses energy. For example, you can burn wood to produce energy in the form of heat and light. But matter also possesses energy in the small particles that make up all matter. Much of the study of electronics is growing to understand how matter can be used to control the flow of electrical energy, how electricity behaves in different types of matter, and how changes in matter affect electricity.

   i. **Reciprocal**—In mathematical relationships, the inverse of a quantity, created by dividing the quantity into 1

   j. **Symbol**—A written character or drawing that represents an object, characteristic, condition, or other defined aspect

   k. **Theorem**—A mathematical formula or logical assumption based on observations that describes a relationship

   l. **Theory**—Statement of a scientific belief

   Note: Much that we believe about the world and how it operates cannot be proved. For example, while we believe that electricity can be explained as the movement of electrons between atoms, there is no way at present that that idea can be shown to be true. Someday, these concepts may be proven, but for now they remain only guesses about how what electricity is.

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m. **Work**—In the science of physics, the use of energy to produce movement

Note: In scientific terms, work occurs whenever energy is used to generate force so that movement occurs. That movement may be a truck hauling tons of dirt, or it may be the controlled movement of electrons through a wire. The results of such work may be a new road or a song played on a compact disc player or one round of a video game.

2. **Areas of employment in the electronics industry**

a. Research and development

b. Manufacturing

c. Sales

d. Repair and service

3. **Areas of scientific study in the electronics industry**

a. Physics—The study of laws and principles that govern how matter and energy behave, including magnetism, electricity, and atoms

b. Mechanics—A field of physics that deals with how force affects bodies and the design and construction of machines to perform work

c. Hydraulics—A field of physics that deals with how liquids can be used to transfer force

d. Pneumatics—A field of physics that deals with how gases, and particularly pressurized air, can be used to transfer force

e. Optics—A field of physics that deals with how light behaves and how it can be used to perform work

f. Chemistry—The study of the composition and structure of substances and their interaction with each other

4. **Electron theory of electricity**

a. All matter is composed of particles called *atoms.*

b. Atoms consist of smaller particles called *neutrons*, *protons*, and *electrons*.

c. Neutrons and protons are grouped together in the center of the atom, called a *nucleus.*

d. Electrons go around the nucleus in circles called *orbits* or *shells.*

e. Electrons in the outer shell are called *valence electrons* and can break away from the atom and become *free electrons.*

f. Other atoms can pick up free electrons and lose electrons from their own valence shells.

Information Sheet

g. The flow of electrons among atoms can be increased by adding energy to them.

h. The flow of electrons due to increased energy constitutes electricity.

i. Substances can be classed by how easily their electrons flow; substances in which electrons flow easily are called *conductors*, those that resist the flow of electrons are called *insulators*, and those that can be made to exhibit characteristics of either conductors or insulators are called *semiconductors*.

5. Electrical characteristics of conductors, insulators, and semiconductors

a. Conductors

- Valence electrons separate from their atoms very easily.
- The ease with which valence electrons separate is called *conductance*.
- Conductance varies from substance to substance and with factors such as temperature, diameter of the conductor, and length of the conductor.
- The conductance of a conductor decreases as its temperature increases.
- Conductors, such as copper, silver, and aluminum, are used to provide electrical flow from point to point.

b. Insulators

- Valence electrons are difficult to separate from their atoms.
- The opposition to losing valence electrons is called *resistance*.
- Resistance varies from substance to substance and with factors such as temperature and the amount of insulator material.
- Insulators, such as rubber and plastic, are used to prevent electrical flow and can be used to wrap conductors to prevent electrical flow when other conductors contact the insulated conductor.
- Some insulators can store electrical charge and are called *dielectrics*.

c. Semiconductors

- Semiconductors have valence shells that are filled to half their capacity with four electrons that are moderately easy to separate.
- Atoms of semiconductors, such as silicon and germanium, can bond together so that their valence shells are filled to form *crystals*.
- Adding heat to a semiconductor can cause valence electrons to become free in the crystal which increases the conductance and decreases the resistance of the material.
- The conductance of a semiconductor can be improved by adding a second substance to the semiconductor that will also bond with the semiconductor

valence shells; the second substance is called an *impurity* and the process of adding impurities is called *doping*.

- If the impurity has five electrons in its valence shell, such as arsenic, the impurity is called a *donor* impurity because it donates a free electron; the extra electrons give the semiconductor a negative charge and the semiconductor is called an *N-type material*.
- If the impurity has three electrons in its valence shell, such as boron, the impurity is called an *acceptor* impurity because it produces an extra hole in the valence shells of the crystal bonds; the extra holes give the semiconductor a positive charge and the semiconductor is called a *P-type material*.
- Electrical flow in semiconductors can occur as a flow of electrons in N-type materials or as a flow of holes in P-type materials.

6. Sources of electricity

a. Triboelectric effect—Production of electrical energy through the friction between two nonconducting objects moving against each other

b. Electrochemical reaction—Production of electrical energy through exposing certain dissimilar metals to acid

c. Electromagnetic induction—Production of electrical energy by moving a conductor through a magnetic field

d. Photoelectric effect—Production of electrical energy when light strikes certain substances

e. Thermoelectric effect—Production of electrical energy by applying heat to the junction of certain dissimilar metals in contact with each other

f. Piezoelectric effect—Production of electrical energy by applying pressure to certain substances with crystalline structures

7. Characteristics of electrical flow

a. Charge—The condition of a material which possesses equal numbers of protons and electrons (neutral charge), excessive numbers of electrons (negative charge), or a shortage of electrons (positive charge)

Note: Charge is measured in *coulombs* (see Objective 8). A coulomb is equal to the charge of 6.25×10^{18} electrons. Charge is sometimes referred to as *quantity of charge* and is represented by the letter Q.

b. Electromotive force (emf)—The pressure that pushes electrons through a material

Note: Electromotive force is measured in *volts*. A volt is defined as the amount of emf required to move one coulomb of charge while using one joule of energy. A volt can also be defined in terms of other electrical characteristics, as explained below. The force required to equalize the difference between charges at two points in a circuit is often referred to as *potential difference*. Potential difference is

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also measured in volts, and emf is often referred to as potential difference or *voltage*.

c. Voltage drop—Difference in the circuit emf as electrical energy enters a load versus the emf as electrical energy exits the load

d. Current—The amount of electrons flowing past a given point in a conductor

Note: Current, sometimes referred to as *intensity*, is measured in *amperes* or amps. An ampere is defined as a rate of flow in which one coulomb of electrons flows past a given point in the circuit in one second. This does not mean the speed at which the electrons are moving, which is generally assumed to be the same as the speed of light. Current refers to the number of electrons (charge) that are moving past the point in one second.

e. Resistance—The amount that a material opposes the flow of electricity through it

Note: Resistance is measured in *ohms.* An ohm is defined as the amount of resistance in a material that would be overcome and allow one ampere of current flow when one volt of emf is applied. Because of this definition, emf and current can also be defined in terms of each other and resistance. One volt is equal to the amount of emf required to move one ampere of current through one ohm of resistance, or one ampere is equal to the number of electrons that will be moved past a point in one second when one volt of emf is applied to a material with one ohm of resistance.

f. Power—The combined effect of current and electromotive force

Note: Power is a measure of work, which is the use of energy to cause movement over a specified period of time. In electrical circuits, that which is moved is electrons. Electrical power is measured in *watts*, with one watt being equal to the amount of work done when one volt of emf produces one ampere of current. The energy used to do work in an electrical circuit is converted to heat, and the higher the circuit resistance the more heat that is produced. The use of energy in a circuit is evident in the voltage drop across a resistance.

g. Conductance—The ease with which a material supports electrical flow

Note: Conductance is the opposite of resistance and can be expressed as the inverse or *reciprocal* of resistance. Conductance is measured in *siemens*. Thus, if a material offers one ohm of resistance, its conductance is one siemen. A material offering 10 ohms of resistance has a conductance of 0.1 siemen.

8. Units of measure for electrical characteristics

	Characteristic	Unit of Measure	Abbreviation	Symbol
a.	Charge	coulomb	C	Q
b.	Electromotive force	volt	V or v	E
c.	Voltage drop	volt	V or v	V
d.	Current	ampere	amp or A	I or I
e.	Resistance	ohm	ohm or Ω	R
f.	Power	watt	W	P
g.	Conductance	siemens	S	G

9. Ohm's Law—$E = I \times R$

Note: Ohm's Law shows the relationship among voltage, current, and resistance. Voltage can be calculated by multiplying current by resistance as shown. By applying mathematical principles, the formula can be changed to solve for resistance by dividing voltage by current or to solve for current by dividing voltage by resistance.

Example: Assume that a circuit with a 10-ohm resistance is operating with a current of 3 amperes. What is its voltage?

$E = I \times R$

$E = 3 \text{ amperes} \times 10 \text{ ohms}$

$E = 30 \text{ volts}$

10. Watt's Law—$P = I \times E$

Note: Watt's Law expresses power as a product of current and voltage. Similarly, current can be determined by dividing power by voltage, or voltage can be calculated by dividing power by current. If resistance is known, but one of the other variables in the formula for Watt's Law is unknown, Ohm's Law can be used to calculate the unknown quantity, which can then be used in the Watt's Law formula.

Example: Assume that a circuit with an applied voltage of 30 volts is operating with a current of 10 amperes. What is its wattage?

$P = I \times E$

$P = 10 \text{ amperes} \times 30 \text{ volts}$

$P = 300 \text{ watts}$

11. Forms of electrical current

a. Direct current (DC)—Electrical flow in which the flow of electrons is in one direction only

b. Alternating current (AC)—Electrical flow in which the current reverses direction periodically

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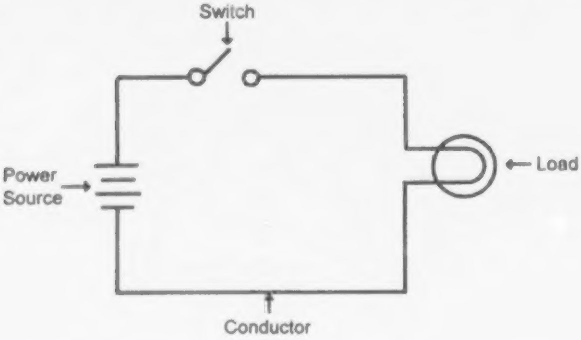
12. **Parts of a simple electrical circuit**

Note: For a circuit to exist, there must be a power source, a load, and a means of connecting them electrically (conductors). Typically, even the simplest circuit will have some sort of control device such as the switch shown in this example. The circuit may also include other devices (see Objectives 29 and 36).



13. **Types of electrical circuit power sources**

    a. Battery—Device in which energy is stored in chemical form

    b. Service power—A utility company provides electricity to a facility, which uses internal wiring to route electricity to wall outlets and other junctions

    c. Generator—Device that uses another energy source to produce mechanical force that is converted into electricity

    Examples: Wind generator, hydroelectric generator, atomic generator

    d. Solar cell—Device that converts light into electricity

14. **Purpose of the ground in an electrical circuit**—To provide a drain for excess electrons

15. **Types of grounds used with electronic equipment**

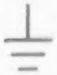
    a. Earth—Excess electrical charge is conducted into the ground via a rod or water pipe

    b. Chassis—Excess electrical charge is conducted into metal frame of the equipment

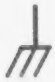
    c. Common connections—Two or more connections are tied to one another

16. **Symbols for grounds used with electronic equipment**

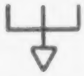
    a. Earth



b. Chassis



c. Common connections



17. Ways of classifying electrical/electronic circuits

Note: There are many ways of classifying electrical and electronic circuits. Some of the more important are listed below and covered in this and other units of instruction in this course. As you learn more about these circuits, you will also study the principles that govern their operation. For the most part, the concepts that you will learn in this unit apply to linear resistive circuits and may or may not apply to other types of circuits.

a. Structure
  - Series
  - Parallel
  - Series-parallel

b. Type of current
  - Direct current
  - Alternating current

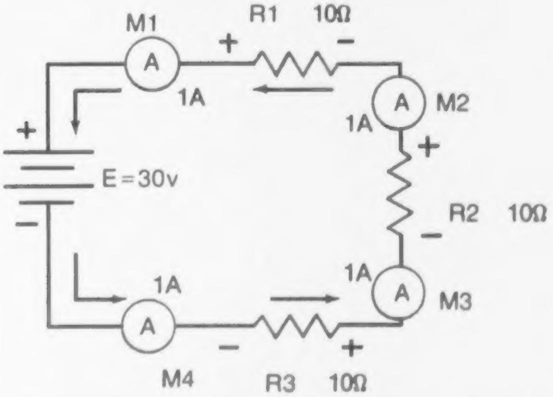
c. Comparison of input to output
  - Linear
  - Nonlinear

d. Component characteristics
  - Resistive (R)
  - Resistive-capacitive (RC)
  - Resistive-inductive (RL)
  - Resistive-capacitive-inductive (RCL)
  - Inductive-capacitive (LC)

e. Type of signal

- Analog
- Digital

18. Flow of electricity in a series circuit



19. Electrical characteristics in a series circuit

a. Charge—Electrons flow from the negative side of the power source to the positive side of the power source

b. Electromotive force

- Total electromotive force is the same as applied voltage.
- Electromotive force at any point in the circuit is equal to the applied voltage less the sum of the voltage drops between the source and that point in the circuit.

c. Voltage drop—The sum of all voltage drops is equal to the applied voltage

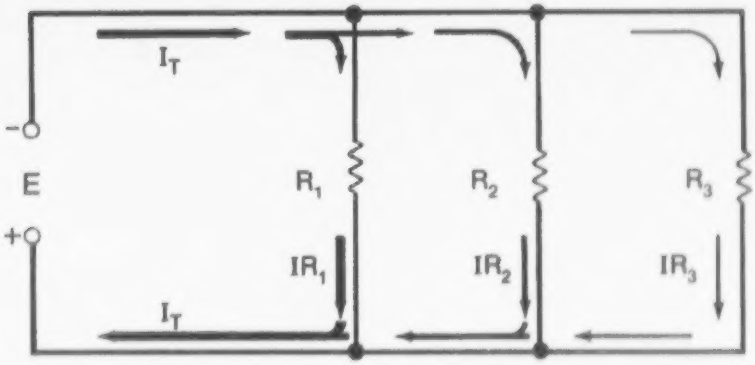
d. Current—Is the same throughout the circuit as computed by Ohm's Law

e. Resistance—Total resistance equals the sum of the resistance values of each portion of the circuit

f. Power—Equals the power of the power source and is the same as the sum of the power across each resistance

g. Conductance—Equals the reciprocal of total resistance with conductance across a portion of the circuit being equal to the reciprocal of the resistance of that portion of the circuit

20. Flow of electricity in a parallel circuit



21. Electrical characteristics in a parallel circuit

a. Charge—Electrons flow from the negative side of the power source to the positive side of the power source

b. Electromotive force (emf)—Is the same as applied voltage at any point in the circuit

c. Voltage drop—In each parallel branch is equal to the applied voltage

d. Current

- For each branch, current is equal to the voltage divided by the resistance of that branch.
- Total current is equal to the sum of the currents across each branch.

e. Resistance

- Total resistance is less than the lowest resistance of any branch.
- Total resistance is equal to the reciprocal of the sum of the reciprocals of the parallel resistances.

Example: $R_t = \dfrac{1}{\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}}$ or $\dfrac{1}{R_t} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3}$

- If the resistance values of each branch are equal, total resistance is equal to the branch resistance divided by the number of branches.

Example: $R_t = \dfrac{\text{R (of individual branch)}}{\text{N (number of branches)}}$

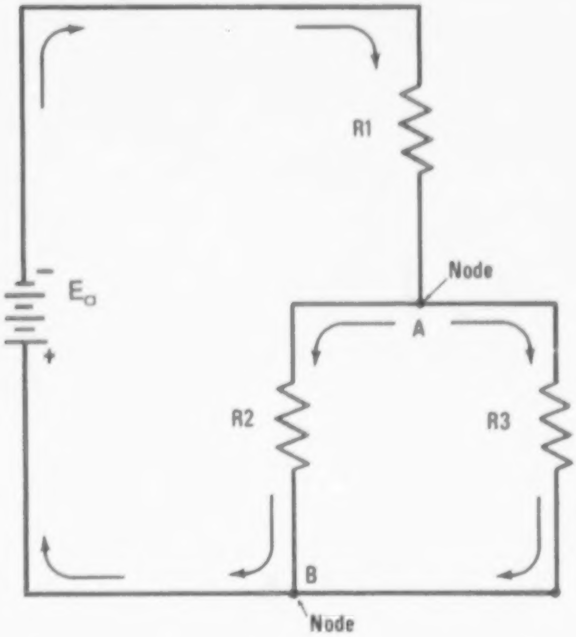
- The total resistance of two parallel branches with unequal resistance values is equal to the product of the two values divided by the sum of the two values.

Example: $R_t = \frac{R_1 \times R_2}{R_1 + R_2}$

f. Power—Equals the wattage of the power source and is the same as the sum of the power of each branch

g. Conductance—Equals the reciprocal of total resistance with conductance across a portion of the circuit being equal to the reciprocal of the resistance of that portion of the circuit

22. Flow of electricity in series-parallel circuit



23. Electrical characteristics in a series-parallel circuit

a. To determine the electrical characteristics of a series-parallel circuit, the circuit is converted to an equivalent series circuit.

- Compute the total resistance for the parallel portion of the circuit

Example: Using the figure in the previous objective with values of R_1 = 30 ohms, R_2 = 20 ohms, and R_3 = 30 ohms,

$$R_{eq} = \frac{R_2 \times R_3}{R_2 + R_3} = \frac{20 \times 30}{20 + 30} = \frac{600}{50} = 12 \text{ ohms}$$

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- Use the equivalent resistance to compute the resistance of a series circuit.
- Repeat these steps for other parallel portions of the circuit until only series elements remain.

b. Once the circuit is converted to a series circuit and the resistances determined, the circuit can be treated like a series circuit to determine other electrical characteristics (current, voltage, conductance, etc.)

24. **Kirchhoff's first law**—The total current flowing through a parallel circuit is the sum of the currents flowing through each branch

25. **Kirchhoff's second law**—The sum of the voltages around a closed loop must equal the applied voltage.

26. **Principle of maximum power transfer**

a. The amount of power that can be transferred from the power source to the load is governed by the resistance of the power source and the resistance of the load.

b. The efficiency of power transfer is defined as the ratio of the output power to the input power.

c. The highest power transfer efficiency occurs when the load resistance is high relative to the source resistance.

d. Maximum power transfer occurs when the resistance of the load is equal to the internal resistance of the power source.

27. **The superposition theorem**—In a linear network with two or more power sources, the current or voltage for any component is the algebraic sum of the effects produced by each source acting separately.

28. **Thévenin's Theorem**—A two-terminal network of linear components and voltage sources can be replaced by an equivalent network containing one voltage source in series with one resistance.

29. **Electrical components used in electronic equipment**

a. Power sources

- Battery—Two or more cells containing a chemical called an *electrolyte* and metal rods or plates called *electrodes* that produce electricity through chemical action
- Power supply—Circuit or device that provides a specific electrical output by converting power from another power source or from another energy source, such as converting AC to DC
- Transformer—Device used to increase (step up) or decrease (step down) AC voltage
- AC source—Supply of alternating current external to the equipment, usually accessed with a power cord

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b. Conductors

- Wire—Thin, flexible, generally metal rod often coated with an insulating substance
- Cable—Method of packaging multiple conductors in a generally round or flat grouping with each conductor individually insulated
- Bus (bus bar)—Metal strip, usually equipped with terminals to which conductors can be attached as part of a common circuit
- Terminal—Method of attaching a conductor to a device often through the use of threaded fasteners or clips
- Connector—Method of attaching a conductor to a device or for joining conductors that usually involves the mating of two parts to form a mechanical and electrical union

c. Switches

- Contact—Device that is actuated electrically, mechanically, or through some other means to complete or break a circuit; usually the conducting portion of another type of switch
- Single-throw, single-pole switch—Switch in which the circuit is completed by the movement of one connecting device
- Double-throw, double-pole switch—Switch in which two circuits are completed by the movement of one connecting device with multiple, electrically independent contacts
- Toggle switch—Switch that provides on and off positions and sometimes additional positions, usually through the actuation of a lever that may lock in place or provide just momentary contact
- Pushbutton—Switch that is usually actuated by depressing a button; actuation of the switch may complete or break the circuit with the actuating button reset by a spring or other mechanism
- Rotary—Switch that generally allows adjustment of a current or analog signal across a range by rotation of the switch; the device may have infinite adjustment across the range or may have step positions across the range that are often notch or *detent* positions for the switch
- Slide—Switch that moves back and forth along a path in a single plane; the device may serve one circuit and allow adjustment of that circuit or it may complete or break different circuits in various positions

d. Loads

- Lamp—Device that converts electrical energy into light
- Speaker—Device that converts electrical energy into vibrations that duplicate recorded or live sound

- Bell—Device that converts electrical energy into movement of a hammer to strike a metal dome to produce a ringing sound
- Buzzer—Device that converts electrical energy into a vibration that produces a low humming sound
- Motor—Device that converts electrical energy into rotary motion to allow work to be done
- Fixed resistor—Device that provides a specific amount of opposition to the flow of current through it
- Variable resistor—Device that opposes the flow of current through it that can be adjusted to change the amount of opposition

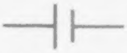
e. Protective devices

- Circuit breaker—Resettable device designed to open a circuit in the event of a potentially dangerous condition, such as overcurrent or high temperatures
- Fuse—Nonresettable device designed to open a circuit in the event of a potentially dangerous condition, such as overcurrent or high temperatures

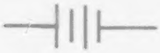
30. Symbols for electrical components used in electronic equipment

a. Power sources

- Battery
  - Single cell



  - Multicell



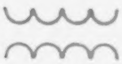
- Power supply

PS

- Transformer

Note: A transformer uses coil windings to regulate electricity. Thus, its symbol consists of two or more induction coil symbols (see Objective 43).

  - Standard symbol



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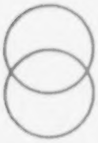
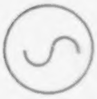
- International symbol

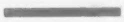


- AC source

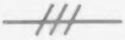


b. Conductors

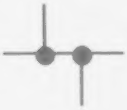
- Wire
  - Conductor (single or multiple)



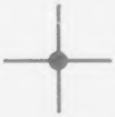
  - Multiple (with number indicated)



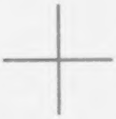
  - Intersection with connection



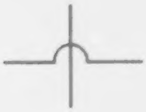
  - Intersection with connection (alternate)



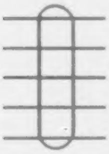
  - Intersection without connection



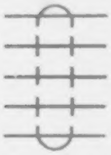
  - Intersection without connection (alternate)



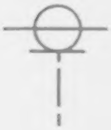
- Cable
  - Multiple conductor (5 conductor shown)



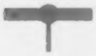
  - Shielded (5 conductor shown)



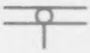
  - Coaxial



- Bus
  - Primary symbol



  - Alternate symbol

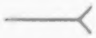


Information Sheet

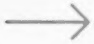
- Terminal

  Connector

  - Female

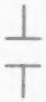
  - Male

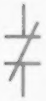
c. Switches

- Contact

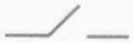
  - Normally open

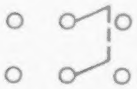
  - Normally closed

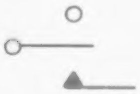
- Single-throw, single-pole switch

- Double-throw, double-pole switch

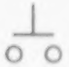
  

- Toggle switch (3-position shown)

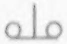
  

Information Sheet

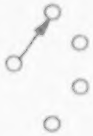
- Pushbutton
  - Normally open



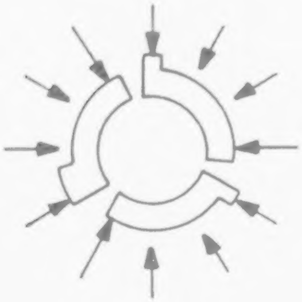
  - Normally closed



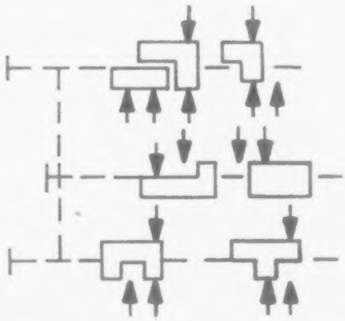
- Rotary
  - General (4-position shown)



  - Section-type



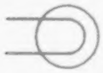
- Slide



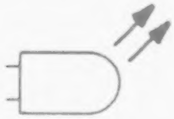
Information Sheet

d. Loads

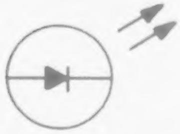
- Lamp
  - Incandescent



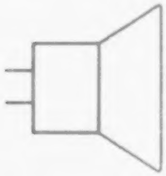
  - General symbol



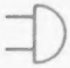
  - Light emitting diode



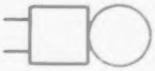
- Speaker (loudspeaker)



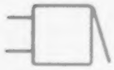
- Bell
  - Equipment bell



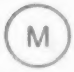
  - Remote bell



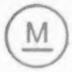
- Buzzer



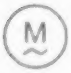
- Motor
  - General



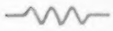
  - DC motor



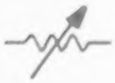
  - AC motor



- Fixed resistor

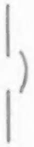


- Variable resistor

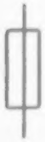


e. Protective devices

- Circuit breaker



- Fuse



31. **Purposes of electrical and electronic circuits**

a. Electrical—Uses electricity to power equipment

b. Electronic—Uses electricity to produce, modify, distribute, and output signals

Information Sheet

32. **Types of information that can be represented by electronic signals**
    a. Sounds
    b. Images
    c. Symbols
    d. Computer instructions
    e. Measured or counted quantities

33. **Types of electronic signals**
    a. Digital signal—Represents an either-or condition in that the signal is either on or off
    b. Analog signal—Represents any value within a range of values

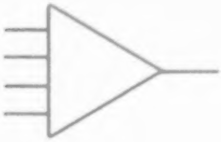
34. **Categories of electronic devices**
    a. Electron tube
    b. Solid-state device
    c. Integrated device

35. **Main functions of electronic devices**
    a. Amplification—Increasing the strength of a signal
    b. Switching—Directing a signal to one or more destinations
    c. Oscillation—Changing direct current into a signal of a specific pattern of vibrations
    d. Energy conversion—Changing one form of energy into another

36. **Functions of electronic devices**
    a. Amplifier—Increases the strength of a signal
    b. Capacitor—Stores electrical charge
    c. Diode (rectifier)—Allows electrical current flow in one direction only
    d. Operational amplifier (op amp)—Amplifies and shifts the signal pattern of its output compared to its input
    e. Thyristor—Provides control functions through the use of one or more internal diodes
    f. Transistor—Amplifies or controls signals as a device that comes in various types of packages generally having three terminals

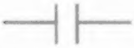
37. Symbols for electronic devices

a. Amplifier (4 inputs, 1 output shown)

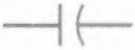


b. Capacitor

- Preferred symbol

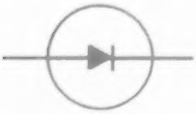


- Alternate symbol

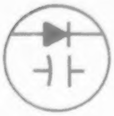


c. Diode (rectifier)

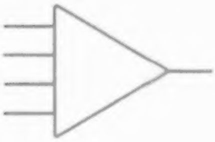
- General symbol



- Capacitive diode



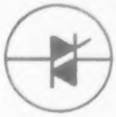
d. Operational amplifier (op amp)



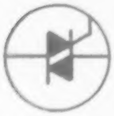
Information Sheet

e. Thyristor

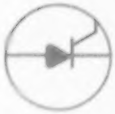
- Diac



- Triac

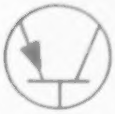


- Silicon-controlled rectifier (SCR)

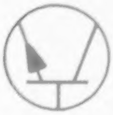


f. Transistor

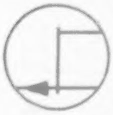
- PNP type



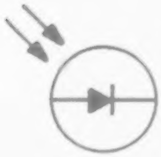
- NPN type



- Field-effect type



- Photo-sensitive type



Information Sheet

38. Magnetic properties

a. Flux—Field of magnetic force that surrounds a magnet; represented by the Greek letter phi (ϕ)

b. Flux density—Measure of the force of a magnet as indicated by the number of lines of flux that pass through a given area; represented by the letter B

c. Magnetomotive force—Amount of force that produces flux around an electromagnet or coil; measured in ampere-turns and abbreviated mmf

d. Field intensity—Flux density around an electromagnet that is a product of the mmf and the length of the coil; measured in ampere-turns/inch and represented by the letter H

e. Permeability—Ease with which a substance concentrates the lines of magnetic force; represented by the Greek letter mu (μ)

f. Reluctance—Opposition to flux; it is the reciprocal of permeability and is represented by the letter R

39. Magnetic characteristics of materials

a. Ferromagnetic—Substances that are readily attracted by magnetic fields

b. Paramagnetic—Substances that are only slightly attracted by magnetic fields

c. Diamagnetic—Substances that are slightly repelled by magnetic fields

40. Ways of classifying magnets

a. Origin

Note: Magnets may be natural or man-made.

b. Permanence

Note: Magnets may be temporary or permanent.

c. Shape

Note: Magnets come in a variety of shapes, the most common of which are bar, ring, and horseshoe.

d. Composition

Note: Magnets can be made from a variety of materials, mostly metallic or ceramic.

Information Sheet

41. **Magnetic flux lines**

    a. The force around magnets takes the form of lines of flux.

    b. The force flows from one part of the magnet (termed the *north pole*), into the space around the magnet, and back to the magnet at a second point (termed the *south pole*) to form loops around the magnet.

    c. Flux lines do not cross each other and tend to restrict themselves to the smallest possible loops.

    d. Like poles repel each other.

    e. Unlike poles attract each other.

42. **Electromagnetism**

    a. When electricity flows through a conductor, a magnetic field is formed around the conductor.

    b. The flow of the field is clockwise as viewed from the negative end of the conductor.

    c. The stronger the electrical current, the stronger the magnetic field.

    d. The magnetic field can be strengthened by winding the conductor into a coil.

    e. The magnetic field can be increased even more by placing a ferromagnetic rod through the loops of the coil.

43. **Induction**

    a. Magnetic induction—A ferromagnetic material will become magnetized if passed through the flux field of a magnet.

    b. Electromagnetic induction—Electrons can be *induced* to flow in a conductor if it is passed through a magnetic field.

44. **Current produced through induction**

    Note: The amount of current induced in a conductor by electromagnetic induction depends on four primary factors. These principles are used to produce electrical current in generators and alternators.

    a. Strength of the magnetic field

    b. Speed of conductor movement relative to the magnet

    c. Angle formed between the conductor and the lines of flux

    d. Amount (length) of the conductor exposed to the field

45. Prefixes used with electrical and electronic terms

	Prefix	Symbol	Decimal Multiplier	Factor of 10
a.	Giga-	G	1,000,000,000.	10^{9}
b.	Mega-	M	1,000,000.	10^{6}
c.	Kilo-	K	1,000.	10^{3}
d.	Milli-	m	0.001	10^{-3}
e.	Micro-	μ	0.000001	10^{-6}
f.	Nano-	η	0.000000001	10^{-9}
g.	Micromicro- or Pico-	μμ ρ	0.000000000001	10^{-12}

Introduction to Electricity and Electronics
Unit 1

Assignment Sheet 1—Apply Ohm's Law

Name ____________________ Overall Rating ____________

Evaluation Criteria	Rating
• Directions have been followed	
• Minimum of 85 percent of answers are correct	

Note: Each correct answer is worth 3 points.

Introduction: The characteristics of electricity can be described by using Ohm's Law. This makes Ohm's Law a useful tool for the electronics technician because it allows for the conversion among the various characteristics. For example, if you know the voltage and amperage of a circuit, then you can use Ohm's Law to calculate resistance.

Directions: Read each of the following problems and apply Ohm's Law to calculate the unknown quantity. Be sure to include the unit of measure with your answer.

	Known characteristics	Unknown quantity
1.	20 amps, 6 ohms	
2.	240 volts, 12 ohms	
3.	240 volts, 4 amps	
4.	4 amps, 60 ohms	
5.	110 volts, 11 ohms	
6.	24 volts, 9.6 amps	
7.	9.6 amps, 2.5 ohms	
8.	440 volts, 20 ohms	
9.	12 volts, 5 amps	
10.	5 amps, 3 ohms	
11.	120 volts, 30 ohms	
12.	230 volts, 5 amps	
13.	0.16 ohms, 75 amps	

Assignment Sheet 1

14. 3 ohms, 24 volts __________
15. 8 amps, 24 volts __________
16. 2×10^{-3} amps, 5×10^{3} ohms __________
17. 1 ohm, 12 volts __________
18. 2 mA, 24 volts __________
19. 1×10^{-6} amps, 10×10^{3} ohms __________
20. 5×10^{-6} volts, 1 ohm __________
21. 3 µA, 12 volts __________
22. 1 Mohms, 8 µA __________
23. 2×10^{-3} volts, 4×10^{-3} ohms __________
24. 5 mA, 1 KV __________
25. 2 Kohms, 2 mA __________
26. 5×10^{6} ohms, 20 KV __________
27. 0.5×10^{-3} amps, 1×10^{3} volts __________
28. 1 amp, 1 ohm __________
29. 0.5×10^{6} ohms, 1 KV __________
30. 5×10^{-3} amps, 2.5×10^{3} volts __________
31. 440 volts, 10 amps __________
32. 120 volts, 40 ohms __________
33. 2 amps, 60 ohms __________

Introduction to Electricity and Electronics
Unit 1

Assignment Sheet 2—Apply Watt's Law

Name ______________________________ Overall Rating ____________________

Evaluation Criteria	**Rating**
• Directions have been followed	____________
• Minimum of 85 percent of answers are correct	____________

Note: Each correct answer is worth 3 points.

Introduction: Like Ohm's Law, Watt's Law provides a method for electronic technicians to work with power in a circuit. Also like Ohm's Law, the formula for power can be rearranged to determine resistance, voltage, or amperage.

Directions: Read each of the following problems and apply Watt's Law to calculate the unknown quantity. Solve for the unknown quantity as indicated by the unit of measure given with the answer blank.

	Known characteristics	Unknown quantity
1.	20 amps, 6 volts	______________ watts
2.	240 volts, 12 amps	______________ watts
3.	240 volts, 4 amps	______________ watts
4.	4 amps, 60 watts	______________ volts
5.	110 volts, 11 watts	______________ amps
6.	24 volts, 9.6 amps	______________ watts
7.	9.6 amps, 2.5 volts	______________ watts
8.	440 volts, 20 ohms	______________ watts
9.	12 volts, 5 amps	______________ watts
10.	6 amps, 3 ohms	______________ watts
11.	120 volts, 30 ohms	______________ watts
12.	230 volts, 5 amps	______________ watts
13.	3 ohms, 75 watts	______________ amps

Assignment Sheet 2

14. 3 ohms, 24 volts ______________ watts
15. 8 amps, 24 volts ______________ watts
16. 2×10^{-3} amps, 5×10^{3} ohms ______________ milliwatts
17. 1 ohm, 12 volts ______________ watts
18. 2 mA, 24 volts ______________ milliwatts
19. 1×10^{-2} amps, 10×10^{3} ohms ______________ watts
20. 5×10^{-3} volts, 1 ohm ______________ milliwatts
21. 3 A, 18 watts ______________ ohms
22. 1 Kohms, 8 A ______________ watts
23. 2×10^{-3} volts, 4×10^{-3} ohms ______________ milliwatts
24. 5 mA, 1 KV ______________ watts
25. 0.2 watts, 2 mA ______________ Kohms
26. 5×10^{6} ohms, 20 KV ______________ watts
27. 0.5×10^{-3} amps, 1×10^{3} volts ______________ watts
28. 1watt, 1amp ______________ ohms
29. 0.5×10^{6} ohms, 1 KV ______________ watts
30. 5×10^{-3} amps, 2.5×10^{3} volts ______________ watts
31. 440 volts, 10 Kwatts ______________ amps
32. 120 volts, 40 ohms ______________ watts
33. 2 amps, 60 watts ______________ ohms

Introduction to Electricity and Electronics
Unit 1

Assignment Sheet 3—Trace Current Flow in Electrical Circuits

Name ______________________________ Overall Rating ________________

Evaluation Criteria	**Rating**
• Directions have been followed	____________
• Current flow is shown correctly on a minimum of 80 percent of the circuits	____________

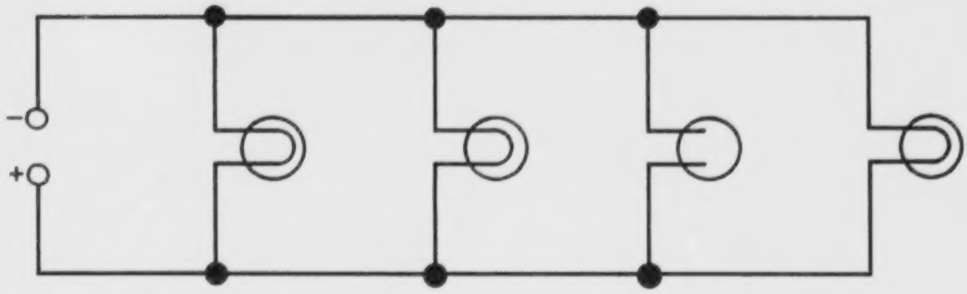
Note: Each correct answer is worth 10 points.

Introduction: In order to understand how electronic circuits operate, the technician must understand how electricity flows through the three basic circuit configurations: series, parallel and series-parallel. Current flow is affected by the layout of the conductors, the use and positioning of switches, loads, and other factors. In this assignment sheet, you will explore variations of the three basic circuit configurations and determine how current flows through the circuits.

Directions: Study each of the circuits illustrated below and determine how current will flow through the circuit based on the conditions shown. Use a heavy-line pen or highlighter to trace the flow of current. Show flow only along those branches that allow current flow; do not indicate current flow along any circuit branch that is interrupted. If there is no current flow anywhere within the circuit, write "No Flow" beside the schematic.

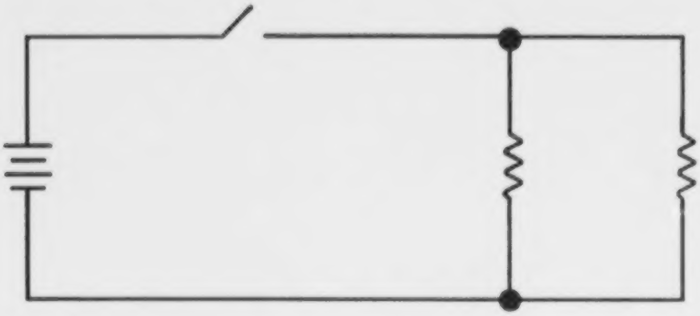
Note: Assume that current flow begins at the negative terminal of the battery and moves to the positive terminal of the battery.

1.

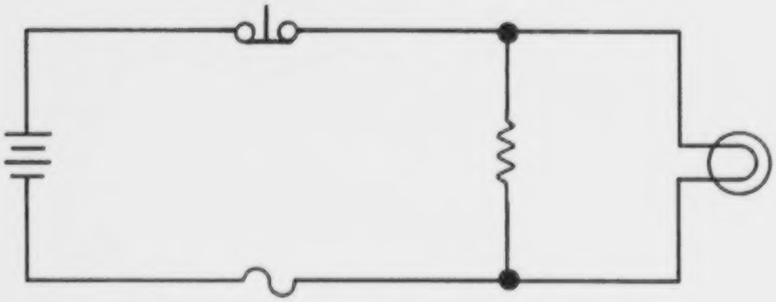


Assignment Sheet 3

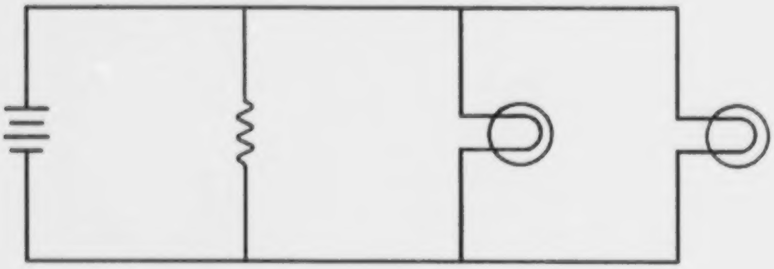
2.



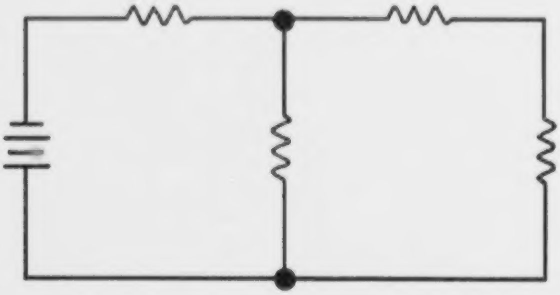
3.



4.

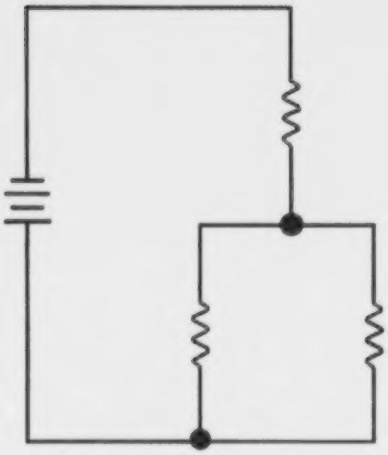


5.

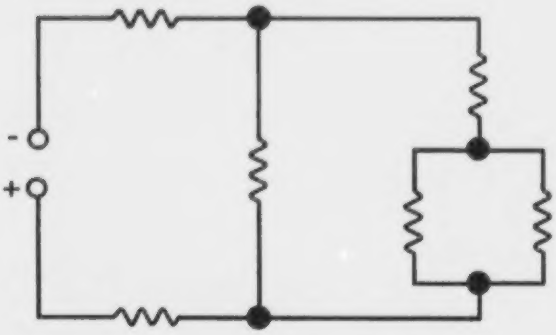


Assignment Sheet 3

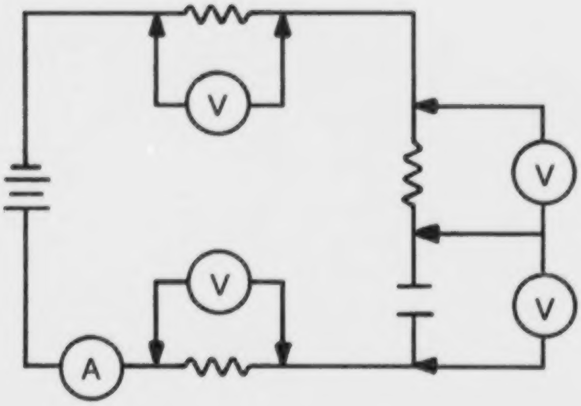
6.



7.

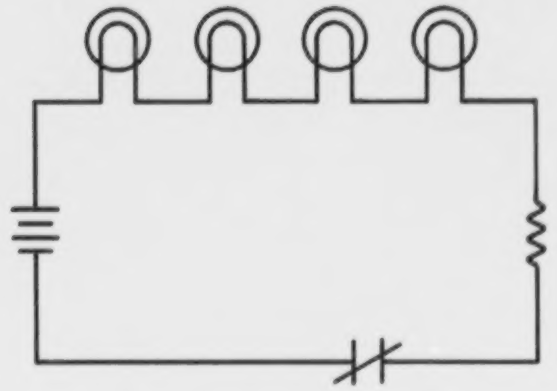


8.

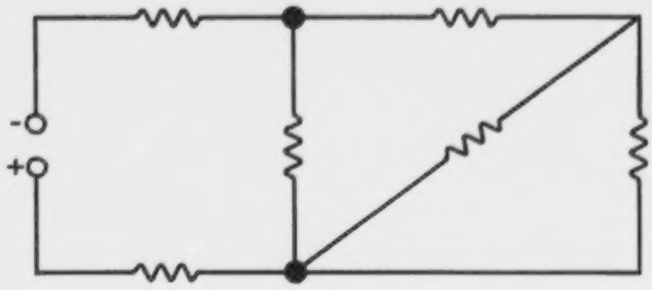


Assignment Sheet 3

9.



10.



Introduction to Electricity and Electronics
Unit 1

Assignment Sheet 4—Apply Kirchhoff's Laws

Name ______________________________ Overall Rating ________________

Evaluation Criteria	**Rating**
• Directions have been followed	__________
• Minimum of 85 percent of answers are correct	__________

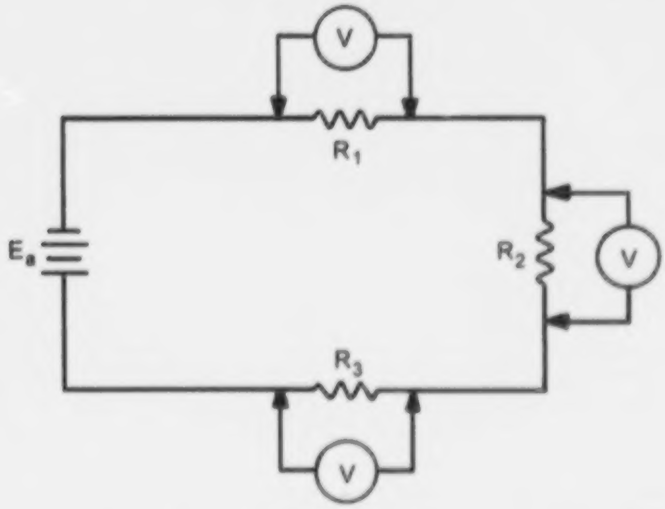
Note: Each correct answer is worth 5 points.

Introduction: Gustav Kirchhoff provided us with two laws important to the study of electricity and electronics. The first is called Kirchhoff's Current Law and states that the sum of the currents entering a point in a circuit will be equal to the sum of the currents leaving that point because charge cannot accumulate in a closed circuit. Kirchhoff's Second Law, or the Voltage Law, states that the sum of the voltages around a closed loop will be equal to the applied voltage. Thus, the voltage increases in a circuit will be equal to the voltage decreases in that same circuit. These laws are useful in designing electrical circuits and in analyzing them in order to troubleshoot or repair a circuit.

Directions: Read each of the following problems and study the schematics that accompany them. Using Kirchhoff's laws, answer the questions that accompany each problem. Write your answers in the spaces provided.

Assignment Sheet 4

Note: Use the following schematic for Problems 1 through 4.



1. In the above circuit, assume that E_a is 12V, the voltage drop across R_1 (V_1) is 6 volts and V_2 is 4 volts. What is the voltage drop across R_3?

____

2. If the applied voltage is 18 volts and V_1 is 6 volts, what is the value of V_2 and V_3 if V_2 and V_3 are equal?

____

3. If V_1 is 8 volts, V_2 is 5 volts, and V_3 is 6 volts, what is the applied voltage?

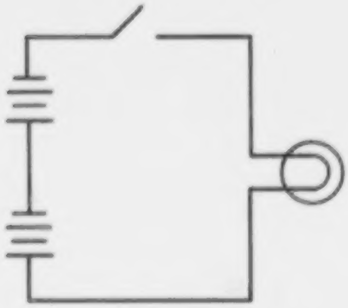
____

4. If the applied voltage is 12 volts and each resistor has the same value, what is the voltage drop across each resistor?

____

Assignment Sheet 4

Note: Use the following schematic for Problems 5 through 7.



5. The above schematic shows a typical circuit for a flashlight, with two batteries in series connected to a circuit with a switch and lamp. What is the total voltage of the circuit if two 1.5-volt batteries are used?

____

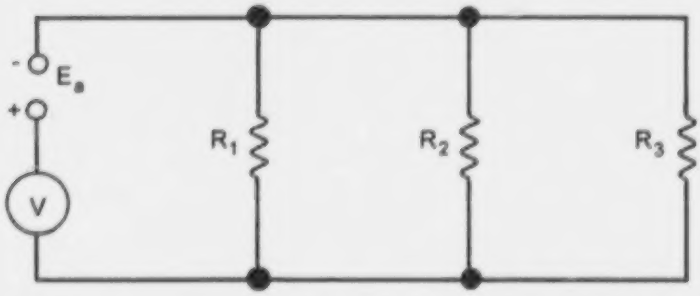
6. What will the total voltage drop be across the circuit?

____

7. If two 3.0-volt batteries are used to power the flashlight, what would the total voltage drop be?

____

Note: Use the following schematic for Problems 8 through 12.



8. Assume that the current across R_1 and R_2 is 2 amps each, while the current across R_3 is 3 amps. What would the reading be on the ammeter?

____

9. If the ammeter reads 15 amps and I_{R1} is 4 amps and I_{R2} is 6 amps, what is I_{R3}?

____

Assignment Sheet 4

10. Answer the following questions for a circuit whose values are E_a = 32v, R_1 = 10 ohms, R_2 = 8 ohms, and R_3 = 12 ohms.

    a. What is I_{R1}? ____________________

    b. What is I_{R2}? ____________________

    c. What is I_{R3}? ____________________

    d. What is the total current? ____________________

11. Answer the following questions for a circuit whose values are E_a = 48v, R_1 = 4.5 ohms, R_2 = 6 ohms, and R_3 = 9 ohms.

    a. What is I_{R1}? ____________________

    b. What is I_{R2}? ____________________

    c. What is I_{R3}? ____________________

    d. What is the total current? ____________________

12. Answer the following questions for a circuit whose **conductance** value across R_1 = 0.20 siemens, across R_2 = 0.08 siemens, and across R_3 = 0.05 siemens if the voltage across R_1 is 24 volts.

    a. What is the resistance across R_1? ____________________

    b. What is the total resistance? ____________________

    c. What is the total current for the circuit? ____________________

Introduction to Electricity and Electronics
Unit 1

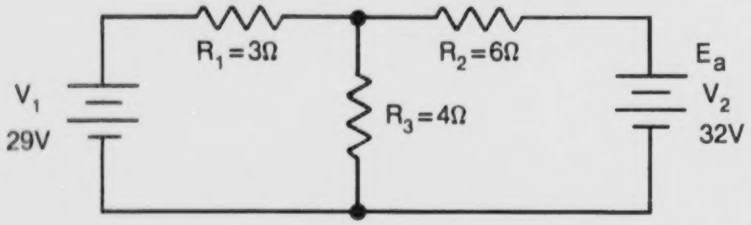
Assignment Sheet 5—Apply the Superposition Theorem

Name ______________________________ Overall Rating ____________

Evaluation criteria	Rating
• Directions have been followed	________
• Minimum of 80 percent of answers are correct	________

Note: Each correct answer is worth 10 points.

Introduction: The Superposition Theorem relates to circuits having two or more power sources. It states that the current or voltage for any component in the circuit is the algebraic sum of the effects of each source acting separately. These values can be calculated by treating the circuit independently for each power source, as shown in the example below:



Step 1: Determine the resistance of the circuit as powered by each power source by adding the resistance values and the equivalent resistance.

$$R_{t1} = R_1 + \frac{R_2 \times R_3}{R_2 + R_3} = 3 \text{ ohms} + \left(\frac{6 \times 4}{6 + 4}\right) \text{ ohms} = 5.4 \text{ ohms}$$

$$R_{t2} = R_2 + \frac{R_1 \times R_3}{R_1 + R_3} = 6 \text{ ohms} + \left(\frac{3 \times 4}{3 + 4}\right) \text{ ohms} = 7.71 \text{ ohms}$$

Step 2: Determine the current for each power source by dividing the voltage of each power source by the total resistance (R_t) for that circuit.

Current of circuit for V_1 is $I_1 = \frac{V_1}{R_{t1}} = \frac{29 \text{ volts}}{5.4 \text{ ohms}} = 5.37$ amps

Current of circuit for V_2 is $I_2 = \frac{V_2}{R_{t2}} = \frac{32 \text{ volts}}{7.71 \text{ ohms}} = 4.15$ amps

Assignment Sheet 5

Step 3: Determine the voltage for each power source through the equivalent resistances by applying Ohm's Law using the equivalent resistance values (R_{eq}).

Voltage for circuit V_1 using equivalent resistance values is

$$ER_{eq1} = I_1 \times R_{eq1} = 5.37 \text{ amps} \times 2.4 \text{ ohms} = 12.89 \text{ volts}$$

Voltage for circuit V_2 using equivalent resistance values is

$$ER_{eq2} = I_2 \times R_{eq2} = 4.15 \text{ amps} \times 1.71 \text{ ohms} = 7.10 \text{ volts}$$

Step 4: Calculate the current across R_3 (IR_3) by adding the current for the two circuits.

$$\text{Current for } R_3 \text{ is } IR_3 = \frac{ER_{eq1}}{R_3} + \frac{ER_{eq2}}{R_3} = \frac{12.89 + 7.1 \text{ volts}}{4 \text{ ohms}} = 5 \text{ amps}$$

Step 5: Calculate the voltage across R_3 (ER_3) by multiplying the current by the resistance.

Voltage for R_3 is $ER_3 = IR_3 \times R_3 = 5 \text{ amps} \times 4 \text{ ohms} = 20 \text{ volts}$

Directions: Use the superposition theorem to determine the current and voltage for each of the circuits described below. Assume that each of the circuits is wired as shown in the above example with the values for power sources and resistors as listed with each problem.

Note: Give your answers rounded to the nearest tenth. To make the calculations easier and the answers more consistent, round to the nearest tenth with each calculation.

Assignment Sheet 5

	V_1 (volts)	V_2 (volts)	R_1 (ohms)	R_2 (ohms)	R_3 (ohms)
1.	28	18	2	2	6
	Current: ________ amperes				
	Voltage: ________ volts				
2.	24	28	4	2	4
	Current: ________ amperes				
	Voltage: ________ volts				
3.	24	32	3	3.5	5
	Current: ________ amperes				
	Voltage: ________ volts				
4.	18	24	2.5	4	4
	Current: ________ amperes				
	Voltage: ________ volts				
5.	22	28	4.5	3	8
	Current: ________ amperes				
	Voltage: ________ volts				

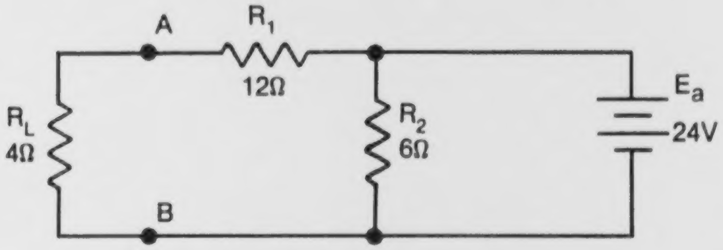
Introduction to Electricity and Electronics
Unit 1

Assignment Sheet 6—Apply Thévenin's Theorem

Name ______________________________ Overall Rating ____________

Evaluation criteria	**Rating**
• Directions have been followed	________
• Minimum of 80 percent of answers are correct	________
Note: Each correct answer is worth 10 points.	

Introduction: Thévenin's Theorem states that any network of linear components such as resistors or power sources can be replaced with an equivalent network without changing the electrical characteristics of the circuit. The network is defined by designating two terminal points in the circuit. The equivalent circuit can be determined by calculating the values of the replaced components within the network. The example below shows the calculations to determine Thévenin equivalents for voltage (E_{th}) and resistance (R_{th}) for the network defined by terminals A and B. This shows that the emphasis under Thévenin's Theorem is the behavior of the circuit across the load (shown as R_L). This perspective is valuable in electronics, especially where system performance can depend on sensitivity to circuit power and resistance values.



To determine the voltage and current across R_L:

Step 1: Calculate the circuit voltage as if the components in the network do not exist; thus, in the example circuit, E_{th} would be equal to the fractional remainder of the circuit voltage not lost in the voltage drops across the resistors.

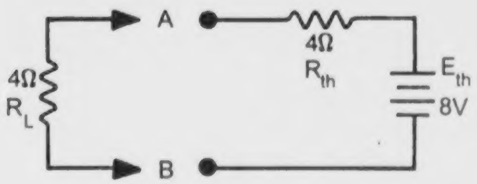
$$E_{th} = \frac{R_2}{R_1 + R_2} \times E_a = \frac{6 \text{ ohms}}{18 \text{ ohms}} \times 24 \text{ volts} = 8 \text{ volts}$$

Assignment Sheet 6

Step 2: Calculate the resistance in the same network as if calculating the resistance for a parallel circuit.

$$R_{th} = \frac{R_1 \times R_2}{R_1 + R_2} = \frac{72 \text{ ohms}^2}{18 \text{ ohms}} = 4 \text{ ohms}$$

Step 3: Construct the equivalent circuit using the Thévenin values for the power source and the linear component values with the network load connected to the terminals A and B; this gives you a series circuit for which you can now use Ohm's Law to solve for circuit current and voltage.



Step 4: Calculate the Thévenin equivalent current (I_{th}):

$$I_{th} = \frac{E_{th}}{R_{th} + R_L} = \frac{8 \text{ volts}}{4 + 4 \text{ ohms}} = 1 \text{ ampere}$$

Step 5: Calculate the load voltage, using Ohm's Law:

$E_{RL} = I_{th} \times R_L = 1 \text{ ampere} \times 4 \text{ ohms} = 4 \text{ volts}$

Directions: Use Thévenin's Theorem to determine the current and voltage in the circuit described in each problem. Assume the same circuit configuration as that used in the example above. Substitute the values listed for the power source and resistors.

Note: Give your answers rounded to the nearest tenth. To make the calculations easier and the answers more consistent, round to the nearest tenth with each calculation. The problems begin on the next page.

Assignment Sheet 6

	E_a (volts)	R_1 (ohms)	R_2 (ohms)	R_L (ohms)
1.	18	2	2	6

Current: __________ amperes

Load voltage: __________ volts

2.	28	4	2	4

Current: __________ amperes

Load voltage: __________ volts

3.	32	3	3.5	5

Current: __________ amperes

Load voltage: __________ volts

4.	24	2.5	4	4

Current: __________ amperes

Load voltage: __________ volts

5.	22	4.5	3	8

Current: __________ amperes

Load voltage: __________ volts

Introduction to Electricity and Electronics
Unit 1

Assignment Sheet 7—Convert Electrical Units of Measure

Name ______________________ Overall Rating ______________

Evaluation Criteria	**Rating**
• Directions have been followed	________
• Minimum of 84 percent of answers are correct	________
Note: Each correct answer is worth 4 points.	

Introduction: The values of electrical characteristics can vary greatly because they are used in a variety of applications. For example, a utility company may generate electricity in megavolt-quantities while an electronic device in a piece of equipment may function in response to millivolt signals. Because electrical characteristic values affect equipment operation, the technician must be able to recognize equivalent values for different units of measure. This assignment sheet will allow you to practice converting among various units of measure used in the electronics industry.

Directions: For each value listed below, write the equivalent value as indicated by the unit of measure given with the answer blank. Write your answers in the blanks provided.

1. 410 A = ________ mA
2. 4.1×10^{6} V = ________ megavolts
3. 15,300 Ω = ________ Kohms
4. 3×10^{-8} seconds = ________ nanosec.
5. 6.7 MW = ________ watts
6. 214 picofarads = ________ μfarads
7. 4.5×10^{6} KV = ________ GV
8. 0.036 mV = ________ μV
9. 47 milliamps = ________ A
10. 9.9 volts = ________ KV
11. 8.4×10^{4} watts = ________ kilowatts
12. 2.13 milliseconds = ________ seconds
13. 17.7 Kohms = ________ Ω

Assignment Sheet 7

14. 5.5 watts = ________ mW

15. 3,175 volts = ________ KV

16. 0.25 amps = ________ mA

17. 8×10^{-6} Farads = ________ ρF

18. 72.5 gigaHertz = ________ kHz

19. 14.4 KΩ = ________ ohms

20. 0.24 μA = ________ mA

21. 1.2 ηsec. = ________ $\times 10^{-8}$ sec.

22. 15,000V = ________ MV

23. 0.023 mA = ________ μA

24. 436 gigawatts = ________ $\times 10^{4}$ W

25. 26.3 mΩ = ________ ohms

Introduction to Electricity and Electronics
Unit 1

Assignment Sheet 8—Interpret Electrical Schematics

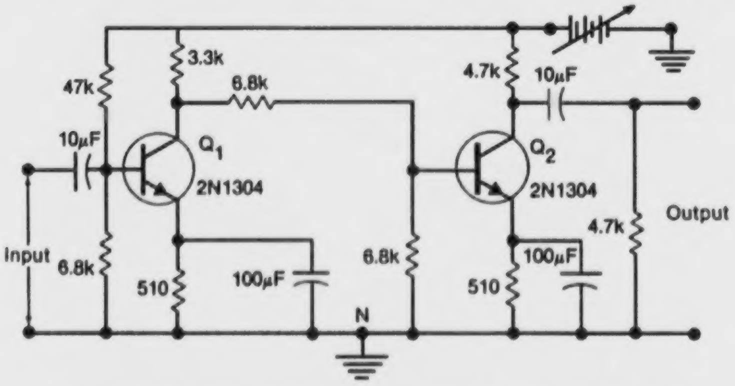
Name ______________________________ Overall Rating ________________

Evaluation Criteria	**Rating**
• Directions have been followed	__________
• Minimum of 84 percent of answers are correct	__________
Note: Each correct answer is worth 4 points.	

Introduction: The electronics industry employs schematic representations of electrical and electronic circuits in order to convey information about actual circuits. The schematics use symbols to represent components as explained in Objectives 30 and 37. In order to understand a circuit, the technician must be able to interpret the schematic correctly. This assignment sheet will allow you to practice interpreting electrical and electronic schematics.

Directions: Study the schematics shown below and on the following pages and then answer the questions with each schematic. Write your answers in the blanks provided. You may refer to the Information Sheet and other resources to assist you in interpreting the schematics.

1.



a. What is the smallest resistor value used in this circuit?

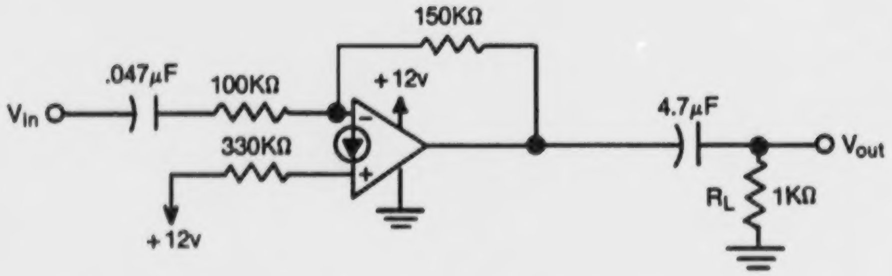
____

b. In the upper right portion of the schematic a symbol is shown that looks like a battery symbol with a line through it. What component does this symbol represent?

____

Assignment Sheet 8

2.


150KΩ
.047µF
100KΩ
+12v
V_{in}
330KΩ
4.7µF
V_{out}
R_L
1KΩ
+12v

a. What is the largest resistor value used in this circuit?

____

b. What is the value of the load resistor?

____

c. To what does the load resistor connect the circuit?

____

d. What type of component is represented by the triangular symbol in the middle of the circuit?

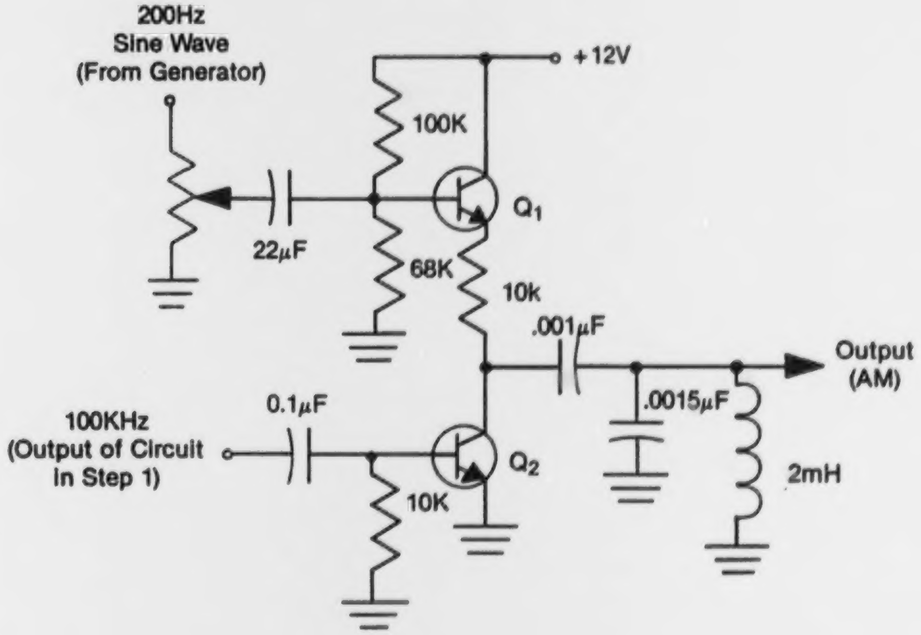
____

e. Two capacitors are shown in the circuit. Do they have the same value?

____

Assignment Sheet 8

3.


200Hz
Sine Wave
(From Generator)
+12V
100K
Q_1
22μF
68K
10k
.001μF
Output
(AM)
0.1μF
100KHz
(Output of Circuit
in Step 1)
.0015μF
Q_2
2mH
10K

a. What is the smallest capacitor value used in this circuit?

____

b. What type of component is shown with a value of 2 mH?

____

c. What is the value of the applied voltage for this circuit?

____

d. What type of component is labeled as Q_1?

____

e. What type of output is provided by this circuit?

____

Assignment Sheet 8

4. Refer to the schematic on the opposite page to answer the following questions.

   a. What type of component is labeled as T105?

   ____

   b. What type of component is labeled as CR101?

   ____

   c. C105 and C106 are shown with arrows passing through them. What do the arrows mean?

   ____

   d. What type of component is labeled as LS101?

   ____

   e. What voltage of battery is used in the circuit?

   ____

   f. What type of component is represented by S101?

   ____

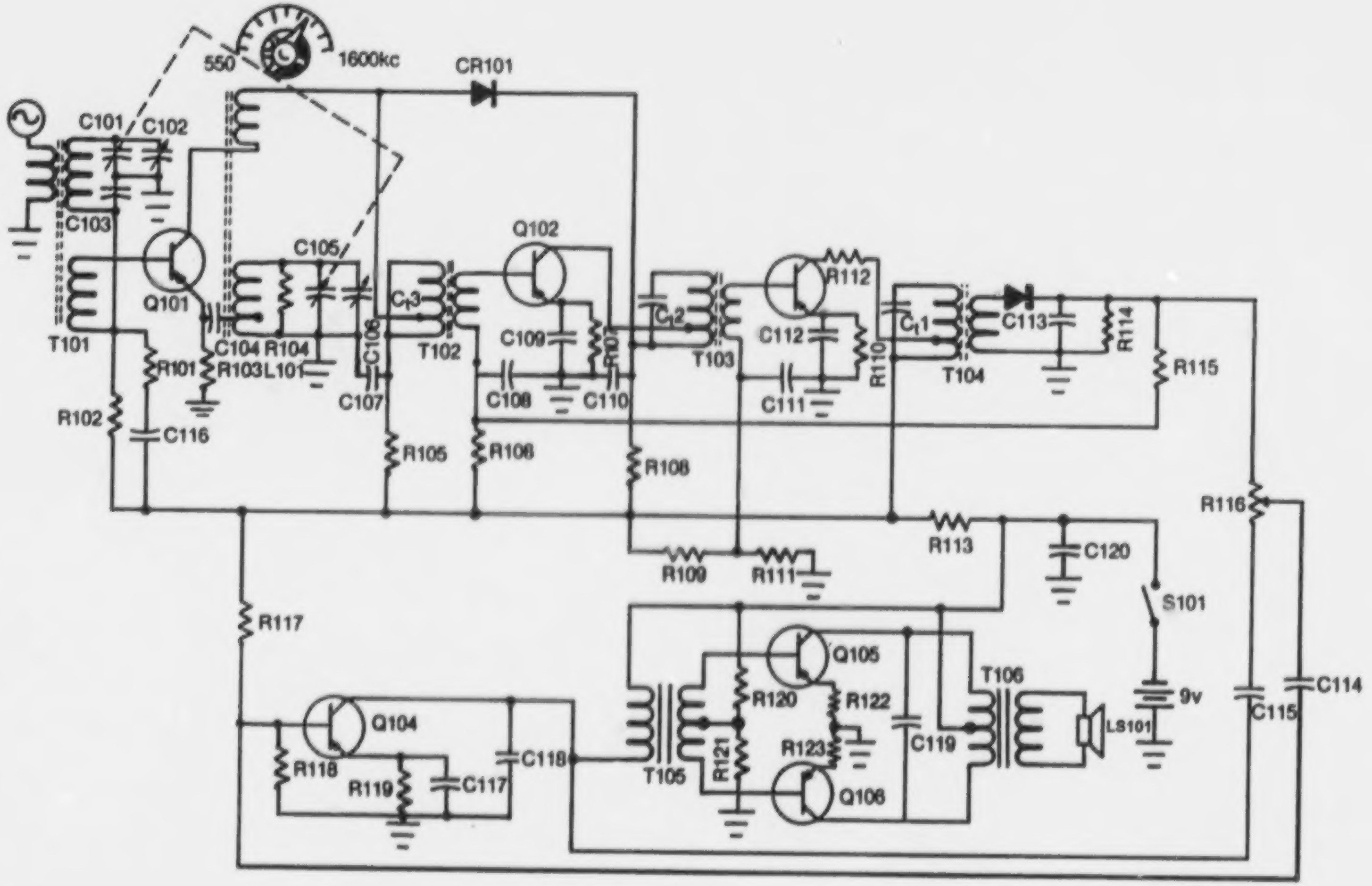
   g. T101 shows that the left coil is connected to a device represented by a circle with a curved line inside it. What does this symbol represent?

   ____

   h. A conductor is attached just above R106 and runs across the circuit, through R115, to a connection near R114. This conductor passes just above R108. Are the conductors connected where they cross above R108?

   ____

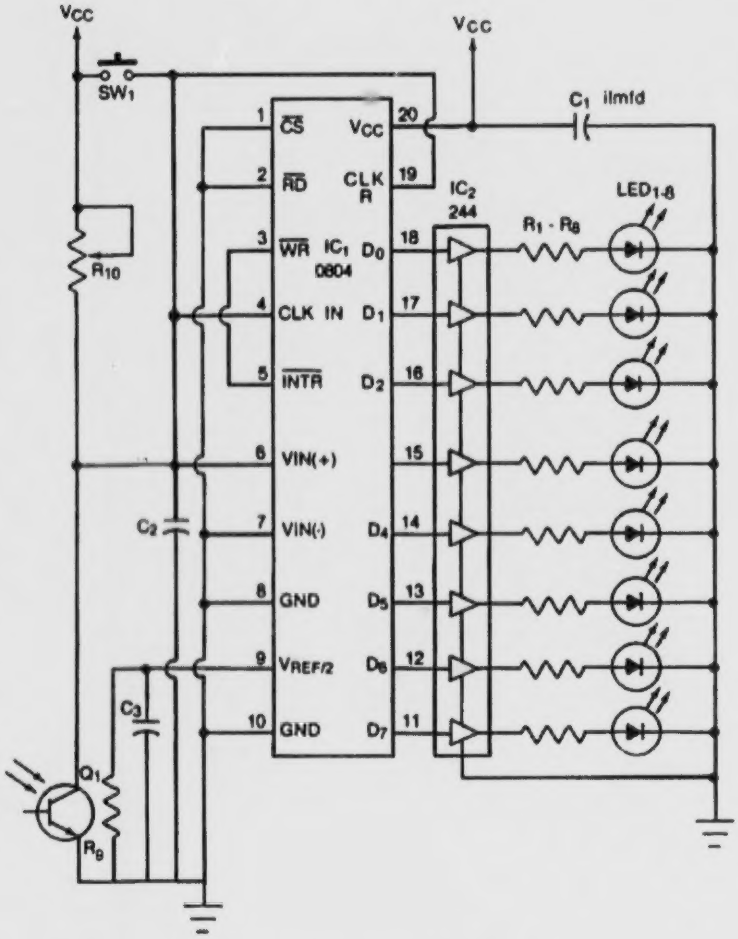
Assignment Sheet 8


550
1600kc
CR101
C101
C102
C103
T101
Q101
R101
R102
C116
C104
R104
R103
L101
C105
C106
C107
C₁3
T102
Q102
C109
R107
C108
C110
R105
R106
R108
C₁2
T103
Q103
R112
C112
C111
R110
C₁1
T104
C113
R114
R115
R116
R109
R111
R113
C120
S101
R117
Q104
R118
R119
C117
C118
T105
R120
R121
Q105
R122
R123
Q106
C119
T106
LS101
9v
C115
C114

GET-57

Assignment Sheet 8

5.


Vcc
SW1
Vcc
C1 ilmfd
1 CS
Vcc 20
2 RD
CLK R 19
IC2 244
LED1-8
R1 - R8
3 WR
IC1 0804
D0 18
4 CLK IN
D1 17
5 INTR
D2 16
6 VIN(+)
15
7 VIN(-)
D4 14
C2
8 GND
D5 13
9 VREF/2
D6 12
C3
10 GND
D7 11
Q1
R9
R10

a. What component is represented by SW1?______________________

b. What component is represented by Q_1?______________________

c. Component IC_2 is an octal buffer. The eight leads on the right side of the octal buffer are connected to conductors that each include a resistor and a second component represented by a circle. What component is represented by the circle?

____

d. A conductor runs between pins 3 and 5 of IC_1 and intersects the conductor coming off pin 4. Do the two conductors connect where they intersect?

____

e. The component labeled as R_{10} serves a special function. What is that function?

____

Shop Orientation and Safety
Unit 2

Objective Sheet

Unit Objective

After completing this unit, the student should be able to discuss shop procedures and policies and apply safety principles and practices. The student should demonstrate these competencies by completing the assignment sheets and job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms associated with shop orientation and safety to their correct definitions.
2. Label the parts of a typical electronics workstation.
3. Match parts of a typical electronics workstation to their correct functions.
4. List types of damage that can occur to electrostatic-sensitive devices.
5. List conditions that promote electrostatic discharge.
6. Match methods for reducing and monitoring electrostatic discharge to their correct descriptions.
7. Identify types of general hand tools used in the electronics workplace.
8. Match general hand tools to their correct uses in the electronics workplace.
9. Match wire preparation and assembly tools to their correct uses.
10. Match soldering tools to their correct uses.
11. Match electronic component handling and preparation tools to their correct uses.
12. Match types of electronic test equipment and inspection tools to their correct uses.
13. Match types of meters to their correct descriptions.
14. Match types of analog meter movements to their correct descriptions.
15. Complete statements about the characteristics and operation of an ammeter.
16. Complete statements about the characteristics and operation of a voltmeter.

Objective Sheet

17. Complete statements about the characteristics and operation of an ohmmeter.

18. Describe the operation of a digital meter.

19. Match oscilloscope controls to their correct functions.

20. Complete statements regarding the operation of an oscilloscope.

21. Select from a list measurements that can be made with an oscilloscope.

22. Label the parts of a waveform display.

23. Match chemicals used in the electronics workplace to their correct applications.

24. Describe types of hazards that may be encountered in an electronics shop.

25. State rules for maintaining a safe work area.

26. Complete statements regarding general workplace safety.

27. Select from a list roles of agencies involved in overseeing safety and public safety in the electronics workplace.

28. Match safety code colors to their correct meanings.

29. Describe electrical hazards in the electronics workplace.

30. Complete statements about electrical shock.

31. List the steps in treating victims of electrical shock.

32. Match chemical hazards in the electronics workplace to their correct descriptions.

33. List ways in which chemicals can enter the body.

34. Match classes of fires to their correct descriptions.

35. Describe high energy hazards in the electronics workplace.

36. Interpret Material Safety Data Sheets. (Assignment Sheet 1)

37. Interpret safety symbols and colors. (Assignment Sheet 2)

38. Determine basic first-aid measures for emergency situations. (Assignment Sheet 3)

Objective Sheet

39. Interpret meter readings. (Assignment Sheet 4)
40. Calculate voltage from sine wave dimensions. (Assignment Sheet 5)
41. Calculate time and frequency from waveform dimensions. (Assignment Sheet 6)
42. Determine phase relationships of AC signals. (Assignment Sheet 7)
43. Lift and move a heavy object. (Job Sheet 1)
44. Operate a fire extinguisher. (Job Sheet 2)
45. Handle and store flammable materials and toxic substances. (Job Sheet 3)
46. Obtain tools from the tool crib. (Job Sheet 4)
47. Measure electrical characteristics in a series circuit. (Job Sheet 5)
48. Measure electrical characteristics in a parallel circuit. (Job Sheet 6)
49. Measure electrical characteristics in a series-parallel circuit. (Job Sheet 7)
50. Adjust oscilloscope controls for a stable waveform display. (Job Sheet 8)
51. Measure frequency using an oscilloscope. (Job Sheet 9)
52. Measure AC voltage using an oscilloscope. (Job Sheet 10)
53. Measure DC voltage using an oscilloscope. (Job Sheet 11)
54. Calibrate an oscilloscope probe. (Job Sheet 12)

Shop Orientation and Safety
Unit 2

Information Sheet

1. **Terms and definitions**

    a. **Calibration**—Process of adjusting test and measurement equipment to a known standard to ensure that the device is accurate

    b. **Crimping**—Method of installing an electrical contact on a conductor by deforming it under pressure

    c. **Cycle**—One complete reversal of an alternating current from negative to positive and back to negative or other sequence of a complete return to a beginning point

    d. **Electrostatic discharge (ESD)**—Transfer of electrical charge as a result of static electricity from one object to another

    e. **Extract**—To remove

    f. **Fastener**—Device used to mechanically join parts

    g. **First aid**—Immediate temporary care given the victim of an accident or sudden illness until the services of a physician can be obtained

    h. **Flammable**—Capable of being easily ignited and burning quickly

    i. **Frequency**—Number of cycles per second for a signal as measured in hertz (Hz)

    j. **Graticule**—Grid lines marking the screen of an oscilloscope, generally in 1-centimeter squares

    k. **Humidity**—Amount of moisture in the air in the form of water vapor

    l. **Insert**—To install a part or assembly into a hole or receptacle intended to receive the part or assembly

    m. **Inspection**—Act of examining a part or assembly visually in an effort to identify defects

    n. **Ion**—An atom or group of atoms that carries either a negative or positive charge

    o. **Material Safety Data Sheet**—Form that lists and explains each of the hazardous materials that an employee works with so that the employee can safely use the material and respond to emergency situations

p. **Phosphor**—Substance that illuminates when bombarded with electrons

q. **Shunt**—Circuit that is wired in parallel with another circuit

r. **Soldering**—Process of joining parts by coating them with a melted alloy of tin and lead and allowing it to harden

s. **Static electricity**—Electrical charge that builds up on objects as a result of the object moving through the air or moving against certain materials such as plastics

t. **Strip**—To remove the insulation from wire or cable

u. **Test**—To exercise an electrical circuit or device to verify that it is functioning correctly, often while using special equipment to measure its performance

v. **Tin**—To coat an exposed conductor with solder to protect it from corrosion or to improve solderability

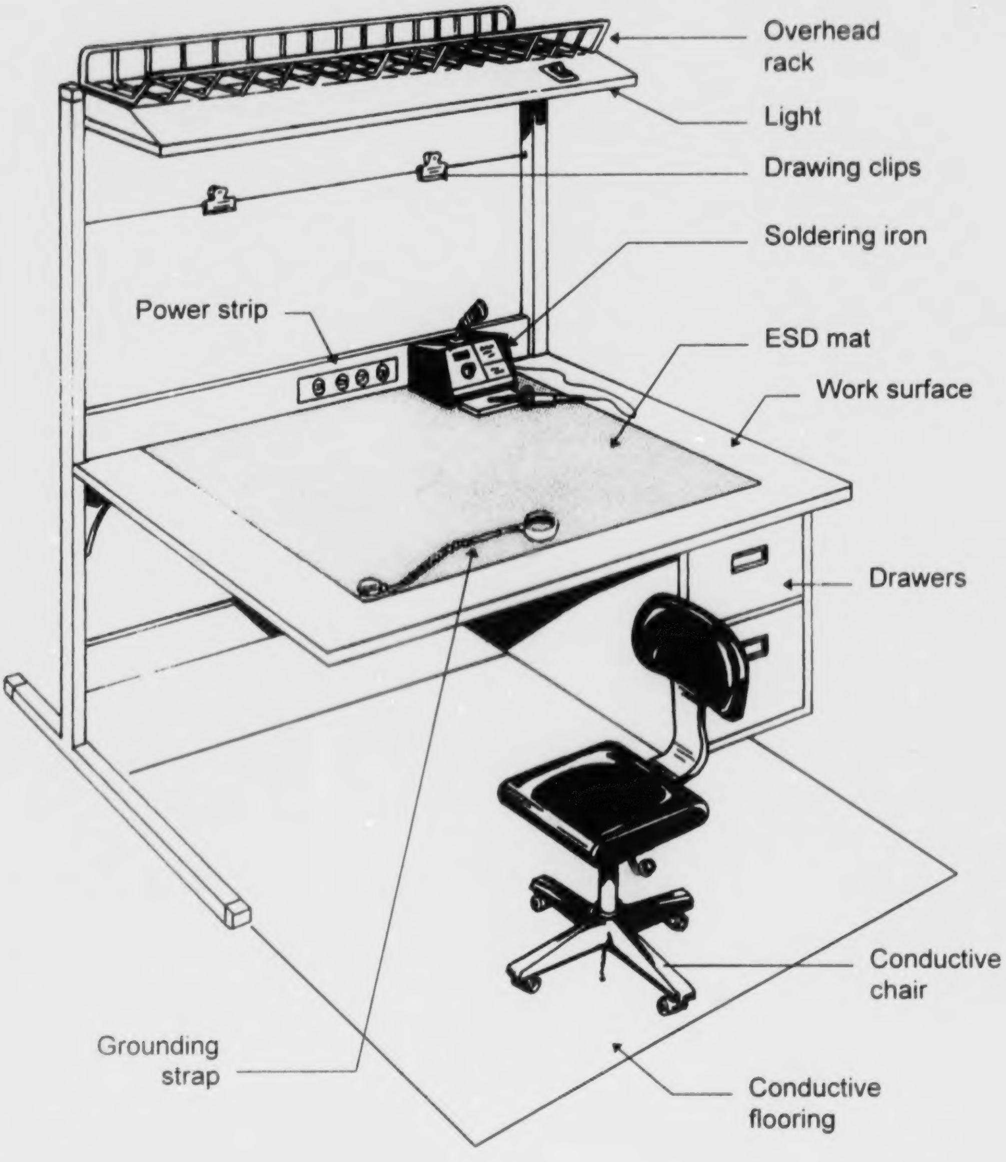
w. **Trace**—Pattern representing a signal as displayed on an oscilloscope

x. **Waveform**—Shape of a trace

2. Parts of a typical electronic workstation

Note: Workstations will vary greatly from facility to facility and with respect to the exact task to be performed. For example, a workstation designed primarily for equipment testing may have several shelves or racks for signal generators, logic analyzers, power supplies, and other devices. The typical workstation shown on the opposite page would be used mostly for fabrication and limited testing. The requirements for any workstation include providing space for the work to be done, accommodations for the worker, support for equipment (such as power and cabling), storage space for tools and reference materials, and considerations for factors such as electrostatic protection and safety grounding.

Information Sheet


Overhead rack
Light
Drawing clips
Soldering iron
Power strip
ESD mat
Work surface
Drawers
Conductive chair
Grounding strap
Conductive flooring

Information Sheet

3. **Functions of the parts of a typical electronic workstation**

   a. Work surface—Provides area on which work is done

   b. Electrostatic discharge mat—Helps maintain work, worker, and work area at same potential difference

   Note: Some workstations have conductive work surfaces and do not require a separate mat.

   c. Grounding strap—Connects worker to ESD mat with an electrically conductive pathway

   d. Conductive chair—Provides seat for worker and conductive pathway to floor

   e. Drawing clips—Holds drawings up for viewing and keeps them off the work area

   f. Soldering iron—Provides heat source for melting solder for parts assembly

   g. Drawers—Hold tools and supplies

   h. Light—Provides illumination for work area

   i. Overhead rack—Provides additional storage space for small, light objects

   j. Power strip—Provides several electrical outlets for tools and test equipment

   k. Conductive flooring—Provides a conductive path to the whole work area and often to an earth ground

   Examples: Floor mat; conductive tile; conductive paint, wax, or epoxy coating

4. **Types of damage that can occur to electrostatic-sensitive devices**

   Note: Most ESD damage is not visible and, in the event of degradation and some other defects, will not be apparent with testing because the malfunction will only occur after a period of time or when the component reaches a certain temperature.

   a. Opens—Breaks in conductors

   b. Shorts—Melting of conductors that allow them to contact other conductors

   c. Destruction of components—Miniaturized components internal to parts and circuit boards are destroyed (burned or melted)

d. Burn holes—Portions of the exterior shell of a part or circuit board are penetrated by a hole that exposes the internal components to the outside environment

e. Degradation—Parts remain functional but may not operate across their full range or may fail sooner than is expected

5. Conditions that promote electrostatic discharge

a. Low humidity

b. Moving air

Examples: Fan-driven air, the part being carried through open air

c. Certain materials

Examples: Plastic, silk and some other cloths, carpet

6. Methods for reducing and monitoring electrostatic discharge

a. Humidifiers—Devices that add moisture to the air to maintain the humidity in the work area within an acceptable range, such as 30 to 70 percent

b. Air ionizers—Electronic devices that reduce the number of free electrons in the air in the area immediately around a work area to reduce the buildup of static electricity

c. Static sprays—Chemicals that can be used to reduce the amount of static buildup in areas where other measures are not practical

Note: Static sprays offer limited protection but must sometimes be used in areas such as carpeted offices where electronic equipment must be used or in carpeted display areas in stores.

d. Conductive surfaces—Surfaces that conduct excess charge from objects and personnel in contact with them to help reduce the buildup of electrical charge

Examples: Conductive flooring tile, conductive resin floors, ESD mats, conductive work surfaces

e. ESD containers—Boxes, bags, plastic sleeves, etc. used to store and carry ESD-sensitive parts and components that reduce the risk of damage either by being conductive or by the use of materials that reduce the buildup of static

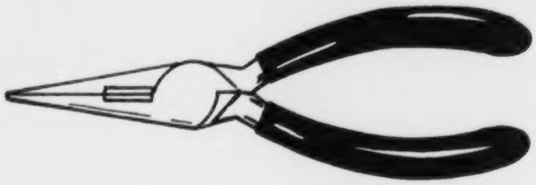
f. Personal straps—Elastic bands, generally used on the wrist or foot, with an internal resistor that helps conduct static charge away from a person's body to minimize the potential difference in the charge of personnel and the area with which they have contact through the band or a conductive cord attached to the band

g. Electronic monitors—Devices that activate an alarm when a discharge event of a certain level has occurred

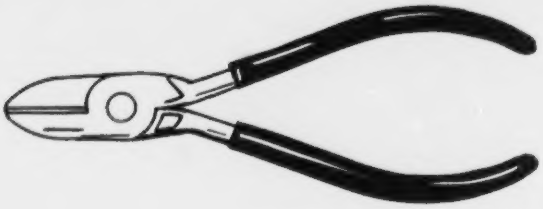
Note: Monitors come in a variety of designs. Some are used to check for ESD events at a workstation, frequently through monitoring the common grounding system of the workstation. Others are installed on equipment, such as printed circuit boards, and are activated if the equipment is exposed to an ESD event.

7. Types of general hand tools used in the electronics workplace

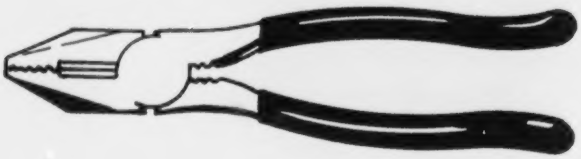
a. Long nose pliers



b. Diagonal cutting pliers

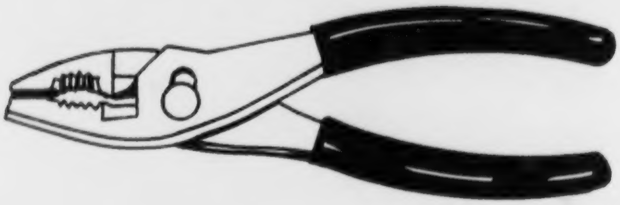


c. Lineman's side cutting pliers

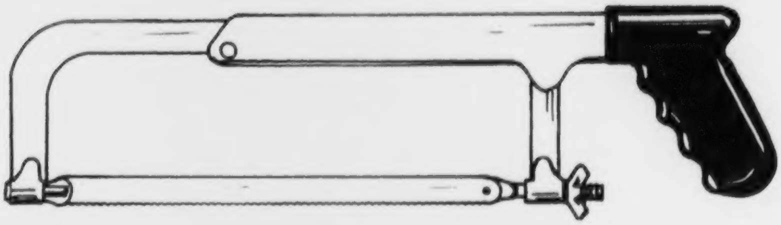


Information Sheet

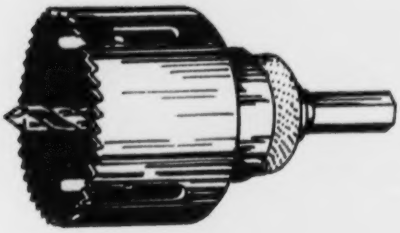
d. Combination slip-joint pliers



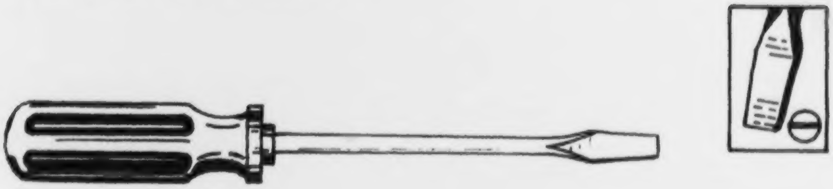
e. Hacksaw



f. Hole saw

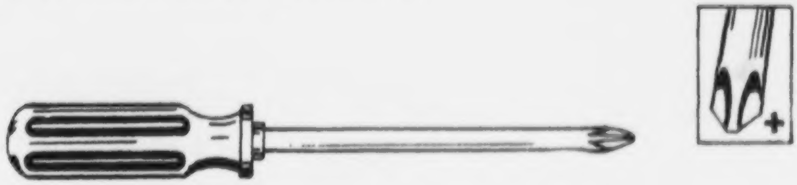


g. Flat-blade (slot-head) screwdriver

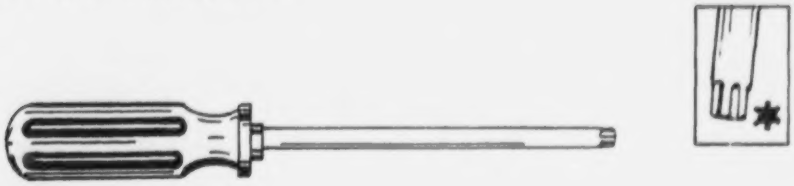


Information Sheet

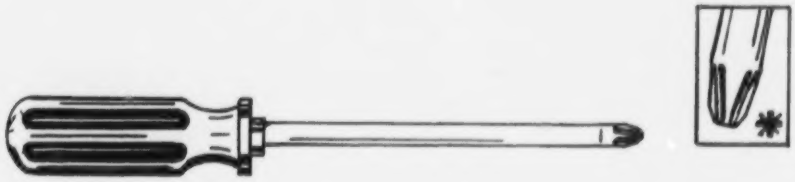
h. Phillips® head (cross-point) screwdriver



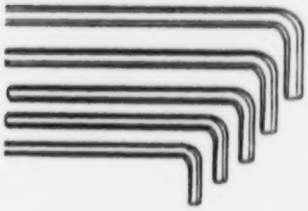
i. Torx® (star fastener) driver



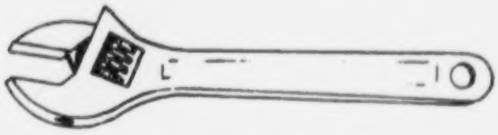
j. Pozidriv® driver



k. Hex and spline (Allen) wrenches

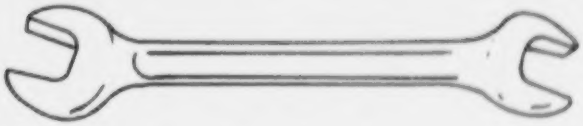


l. Adjustable wrench

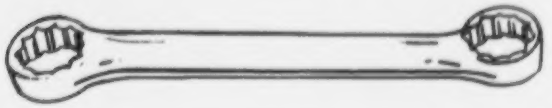


Information Sheet

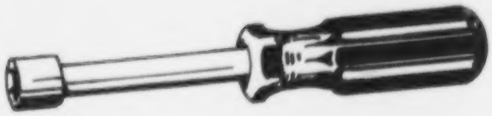
m. Open-end wrench



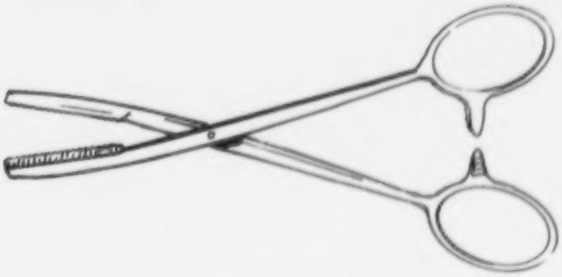
n. Box-end wrench



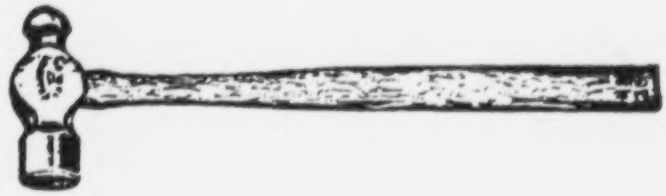
o. Nut driver



p. Hemostat clamp

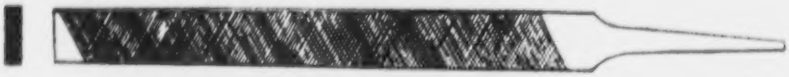


q. Ball peen hammer

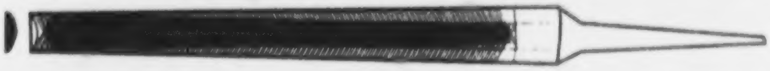


Information Sheet

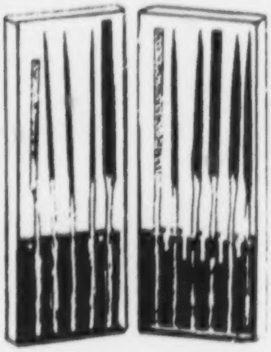
r. Flat file



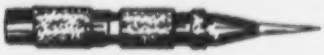
s. Half-round file



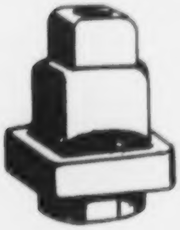
t. Precision files



u. Center punch



v. Square-hole punch



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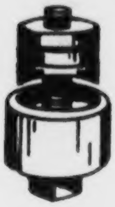
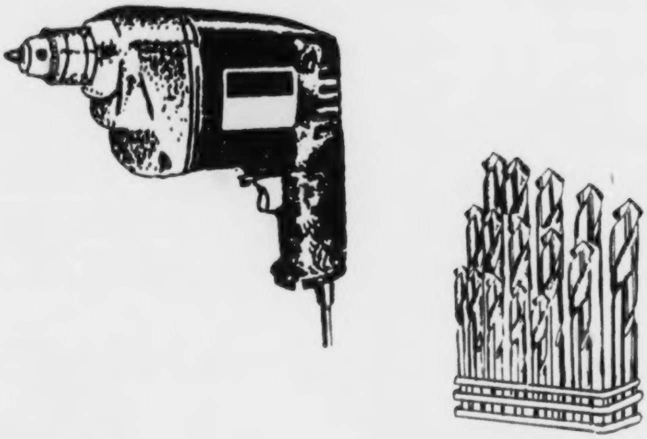
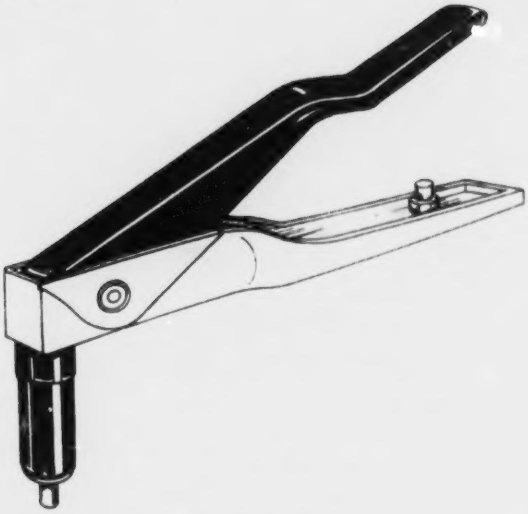
w. Round-hole punch



x. Drill and drill bits



y. Rivet gun



Information Sheet

8. **Uses for general hand tools used in the electronics workplace**

   a. Long nose pliers—Holding components and parts; shaping and forming small conductors and component leads; reaching into tight areas

   b. Diagonal cutting pliers—Cutting wire and component leads; stripping insulation from wire

   c. Lineman's side cutting pliers—Cutting heavy conductors and cables and small metal parts; stripping insulation from wires; forming heavy conductors

   d. Combination slip-joint pliers—Holding or turning components and parts; forming heavy conductors

   e. Hacksaw—Cutting fasteners and metal parts

   f. Hole saw–Cutting large holes

   g. Fastener drivers—Installing or removing threaded fasteners with specific head designs

   h. Hex and spline (Allen) wrench—Installing or removing threaded fasteners such as socket cap screws and set screws with hex slots

   i. Wrenches—Tightening, loosening, or holding nuts and bolts

   j. Nut driver—Tightening, loosening, or holding light-duty nuts and bolts

   k. Hemostat clamp—Holding wires and small parts

   l. Ball peen hammer—Driving punches; installing and removing some types of fasteners

   m. Flat file—Removing rough edges on cut metal straight edges

   n. Half-round file—Removing rough edges on large cut metal holes

   o. Precision file—Finishing small metal surfaces such as small drill holes and some solder joints

   p. Punches—Making holes or indentations of specific shapes; installing or removing pins and removing rivets

   q. Drill and drill bits—Making holes; tightening or loosening threaded fasteners

Information Sheet

9. **Uses for wire preparation and assembly tools**

    a. Mechanical wire stripper—Removing insulation from wire by hand

    b. Thermal wire stripper—Removing insulation with heat

    c. Programmable wire stripper—Removing insulation automatically with precise settings

    d. Electrician's six-in-one tool—Cutting wire, stripping insulation from wire, measuring strip lengths; also provides crimping, bolt cutting, and thread gauge capabilities

    e. Utility knife—Cutting and removing insulation from cables; separating cable strands

    f. Crimping tool—Compressing the barrels of sleeve-type connectors to create a mechanical bond with a wire

    g. Pin insertion and removal tools—Installing and removing pins in or from connector bodies

    h. Heat gun—Shrinking heat shrink tubing

    i. Wire gauge—Measuring wire diameters

10. **Uses for soldering tools**

    a. Wave soldering machine—Soldering entire circuit boards by running them across a vat of solder in which a wave has been produced

    b. Hand soldering machine—Hand soldering of components where precise temperature and power controls are required or preferred

    c. Soldering iron and stand—Hand soldering where low power outputs are acceptable

    d. Soldering gun and stand—Hand soldering in a medium power and temperature range, especially where less precise solder joints are involved

    e. Solder wick—Removing excess solder from a connection

    f. Solder sucker—Removing excess solder or desoldering connections through suction created by a spring-loaded piston

Information Sheet

g. Desoldering bulb—Removing excess solder or desoldering connections through suction created by manually squeezing a rubber bulb

h. Circuit board vise—Holding circuit boards and other assemblies so that they can be soldered or otherwise worked on

i. Hot plate—Providing a source of heat so that soldering or desoldering temperatures are not dissipated as quickly

j. Heat sink—Increasing the thermal mass of a connection to be soldered so that the component does not get exposed to as much heat

k. Reflow equipment—Installing surface-mount components

11. Uses for electronic component handling and preparation tools

a. Lead-forming tools—Shaping leads one at a time

b. Lead-forming dies—Shaping the leads on multiple-lead components

c. Component lead cleaner—Removing oxidation and contaminants from component leads

d. Component insertion tools—Holding components for installation

e. Component extraction tools—Removing components

f. Tinning equipment—Applying a thin layer of solder on component leads to protect them from oxidation and to improve solderability

g. Vapor degreaser—Cleaning components and assemblies with solvents

h. Aqueous cleaner—Cleaning components and assemblies with water-based solutions

12. Uses for types of electronic test equipment and inspection tools

a. Oscilloscope—Displaying representations of voltage against time

b. Function generator—Providing a voltage source with various known waveforms

c. Signal generator—Providing signal outputs, such as audio waveforms

d. Logic probe—Identifying logic levels in digital circuits

Information Sheet

e. Logic pulser—Injecting short bursts of signals into digital circuits

f. Logic clip—Identifying logic levels of an integrated circuit over which it fits

g. Bridge—Measuring electrical characteristics at very precise levels

Examples: Resistance bridge, inductance bridge, capacitance bridge

h. Component testers—Testing specific types of components such as transistors and diodes

i. Cleanliness tester—Measuring the amount of contaminants on a component or circuit board

j. Continuity tester—Measuring the output of wires and conductors in a cable to ensure continuity

k. Bed-of-nails tester—Testing the functionality of circuit boards and other assemblies

l. Power supply—Providing controlled levels of voltage

m. Isolation transformer—Providing AC from a source that is electrically isolated from utility power

n. Inspection scope—Magnifying assemblies and components for visual inspection

o. Ultraviolet inspection light—Inspecting conformal coating on circuit boards

p. Optical comparator—Comparing an assembly to a standard assembly to determine differences between the two

13. **Types of meters**

a. Voltmeter—Measuring voltage or current

b. Ammeter—Measuring current

c. Ohmmeter—Measuring resistance or voltage

d. Multimeter—Measuring various electrical characteristics

14. **Types of analog meter movements**

a. Moving coil (D'Arsonval)—Polarity-sensitive DC meter movement produced with a horseshoe magnet, soft-iron core, and movable coil

Information Sheet

b. Taut-band—DC meter movement with a horseshoe magnet and an iron core attached to two tightly stretched metal ribbons to reduce friction and provide greater sensitivity in meter movements

c. Electrodynamometer—DC and low frequency AC meter movement that uses two stationary coils in place of a magnet; provides low sensitivity

d. Iron vane—Low frequency AC meter movement that uses an iron core inside a stationary coil that acts like a plunger to cause needle movement

e. Thermocouple—Wide-range AC meter movement whose moving coil is connected to a heat-sensitive device to provide more accurate readings

15. Characteristics and operation of an ammeter

a. Ammeters are connected in series with the circuit being tested.

b. The sensitivity of an ammeter is the amount of current required to cause full-scale deflection of the pointer.

c. The full-scale range of the ammeter can be extended through the use of a shunt resistor in parallel with the meter movement.

Note: A *shunt circuit* is one that branches off from the main circuit to by-pass a component or portion of the main circuit. By adding a shunt circuit with a known resistance value, the effective range of the ammeter can be extended.

16. Characteristics and operation of a voltmeter

a. Voltmeters are connected in parallel with the circuit being tested.

b. Because the voltmeter is connected in parallel to the circuit, the meter resistance affects the circuit measurement and, therefore, should be very high.

c. Polarity must be observed when using a voltmeter.

d. Voltmeters can be used to measure either voltage or current.

e. The sensitivity of a voltmeter is the reciprocal of the full-scale current range and is expressed as *ohms/volt*.

f. Many voltmeters have internal circuits that allow selection of different voltage ranges.

g. The full-scale voltage range of the voltmeter can be extended through the use of a multiplier resistor connected in series with the meter movement.

Information Sheet

17. Characteristics and operation of an ohmmeter

a. The ohmmeter contains a battery power source that replaces the power source portion of the circuit.

b. Power must be removed from the circuit before using an ohmmeter.

c. Ohmmeters can be used to measure either resistance or voltage.

d. Many ohmmeters use multiplier resistors and shunt resistors to provide multiple resistance ranges.

e. The multiplier resistors are used to connect the meter in series with the circuit and measure resistance.

f. The shunt resistors are used to connect the meter in parallel with the circuit to measure voltage.

18. Operation of a digital meter

a. Digital meters provide the same functions as analog meters but use digital circuitry and displays.

b. The digital circuitry consists of four functional blocks: a signal processor, an analog to digital converter, a control unit, and a digital readout.

c. Most digital meters automatically adjust their range and select the correct polarity.

19. Oscilloscope controls

Note: The controls listed are typical of many oscilloscopes. As with most electronic equipment, oscilloscope controls are normally labeled on the device, though often with abbreviations and those may vary from the terms used here. Familiarize yourself with any equipment that you have to use.

a. Power switch—Turns oscilloscope on and off

b. Scale illumination switch—Overlays the graticule on the display

c. Focus control—Adjusts image clarity and sharpness of waveform presentation

d. Calibration control—Provides signal to allow the oscilloscope to self-adjust for accurate measurements

e. Intensity control—Adjusts image brightness

f. Sweep mode control—Selects channel to be displayed

g. Horizontal position control—Moves image to the left or right on the display

h. Sweep control—Selects rate of horizontal movement across display

i. External horizontal input—Provides for an external input to allow control of the horizontal sweep by an external signal

j. Trigger source control—Selects the signal to initiate the sweep

k. Trigger level control—Selects voltage level of the triggering waveform that initiates the sweep

l. External trigger—Provides for the input of an external voltage to be used as the trigger that initiates the sweep

m. Vertical position control—Adjusts the image up or down on the display

n. Coupling control—Selects between AC and DC inputs

o. Channel A and Channel B input—Provides connections of input voltages to each of the two channels

20. Operation of an oscilloscope

a. An oscilloscope consists of a chassis that contains processing circuitry, a control panel, a connector panel, and a display.

b. The processing circuitry provides control over the way signals are displayed.

- The horizontal amplifier allows an external input to be displayed on the horizontal axis and amplifies the signal from the sweep generator.
- The sweep generator produces a horizontal trace across the screen.

c. Most oscilloscopes use a cathode ray tube (CRT) display.

- An *electron gun* at the rear of the CRT sends a fine beam of electrons that duplicates the waveform of the input signal.
- The electrons strike a *phosphor coating* on the screen of the display.
- The phosphors glow when struck by electrons, transmitting light through the display glass.

Information Sheet

- *Electrostatic plates* deflect the electron beam to position where it hits the screen.

- The electrostatic plates are adjustable to change the position of the image on the screen, with a set of two plates providing vertical adjustment and a second set of plates providing horizontal adjustment.

21. Measurements that can be made with an oscilloscope

a. Shape of a voltage waveform

b. Phasing of waveforms

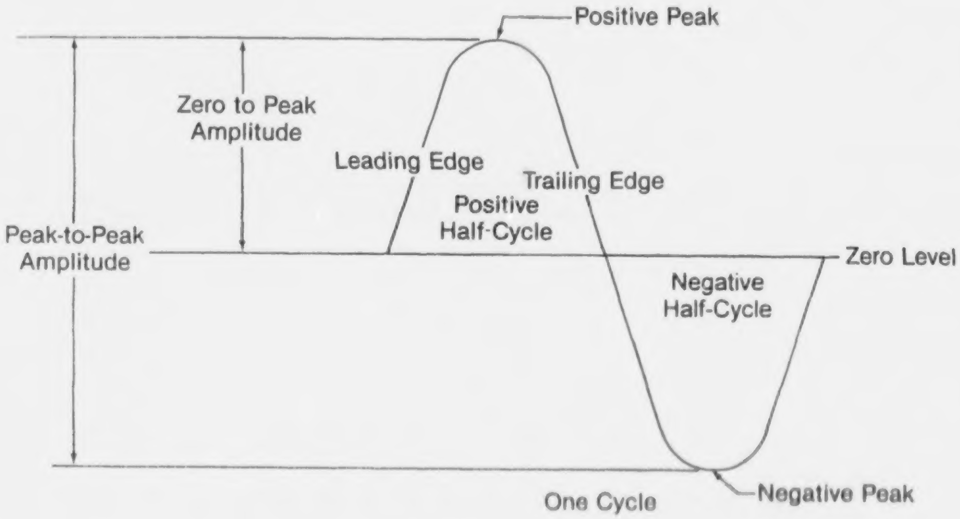
c. Frequency of waveforms

d. Total voltage

e. Peak voltage

f. Peak-to-peak voltage

22. Parts of a waveform display


Positive Peak
Zero to Peak Amplitude
Leading Edge
Trailing Edge
Positive Half-Cycle
Peak-to-Peak Amplitude
Zero Level
Negative Half-Cycle
One Cycle
Negative Peak

Information Sheet

23. Chemicals used in the electronics workplace

a. Ethyl alcohol—Used to clean solder connections and to thin rosin

b. Isopropyl alcohol—Used to remove oil, grease, and flux

c. Acetone—Used to remove oils, grease, paint, and lacquer

d. Hydrochloric acid—Used to clean metal

e. Ketone—Used to thin lacquer and paint

f. Lacquer thinner—Used to thin lacquer and ink

g. Perchlorethylene—Used as general purpose cleaner and in vapor degreasers

h. Inks—Used to label parts and circuit board locations

i. Conformal coating—Used to cover circuit boards to protect them from moisture

j. Potting compound—Used to fill in connector bodies

24. Types of hazards that may be encountered in an electronics shop

a. Electrical shock—Condition that results from electrical current entering the body that can lead to burns, muscle damage, or death as a result of the heart stopping or disruption of the nervous system

b. Burns—Damage to the skin, muscles, or organs as the result of exposure to high temperatures, high intensity lights, electrical shock, radiation, or chemicals

c. Electrical fires—Burning of electrical components and devices that can cause property damage or injury as a result of the fire or through the production of poisonous gases and smoke

d. Chemical poisoning—Condition in which substances enter the body and interfere with its normal functioning

e. Cuts and abrasions—Bodily injuries that generally result from the improper use of tools or flying debris, such as wire and lead clippings

f. High energy exposure—Injuries that result from being exposed to high intensity light such as lasers (blindness and burns), high-frequency sound waves (temporary or permanent deafness), microwaves (bone and joint damage and burns), or radiation (burns, radiation sickness, genetic deformities in offspring)

Information Sheet

25. Rules for maintaining a safe work area

a. Keep all tools clean and in good working order.

b. Do not remove safety devices, such as guards, grounding straps, switch covers, without permission of your instructor.

c. Keep the workplace clean and orderly; dispose of all litter and clean up spills immediately.

d. Do not leave power equipment unattended.

e. Isolate power voltages from ground by means of isolation transformers.

f. Store chemicals in suitable containers in proper storage areas.

g. If you must use chemicals in the work area, take only as much as you think that you will need to do the job.

26. General workplace safety

a. Report all tool defects and safety problems to your instructor.

b. Report all accidents to your instructor regardless of how minor they may seem.

c. Do not energize or operate any equipment without first receiving instruction on its safe operation.

d. When measuring voltages, be careful not to come into contact with any conductors.

e. If a voltage is expected to exceed 30 volts, turn off or disconnect the equipment prior to connecting test equipment.

f. Do not use any solvents, paints, lacquers, or other chemicals without first reviewing the MSDS or receiving instruction on the use of the substance.

g. Do not wear rings, watches, or jewelry when working with electrical or electronic equipment.

h. Do not engage in horseplay or practical jokes in the work area.

i. Wear appropriate clothing, including safety glasses when required.

Information Sheet

27. Roles of agencies involved in overseeing safety and public safety in the electronics workplace

a. Occupational Safety and Health Agency (OSHA)—Is responsible for ensuring compliance with federal legislation governing safe and healthful working conditions for employees

b. Environmental Protection Agency (EPA)—Oversees the use of and proper disposal of chemicals and other products that might present health or environmental hazards

c. Underwriters Laboratories (UL)—Conducts testing to determine the degree of safety designed and built into electrical and other devices

28. Safety code colors

a. Federal safety red

- Indicates danger
- Indicates fire-protection equipment and its location
- Identifies portable containers for explosive or flammable liquids
- Identifies emergency stop bars, stop buttons, and electrical stop switches on machinery

b. Federal safety yellow

- Indicates caution and marks physical hazards
- Indicates waste containers for explosive or combustible materials
- Indicates equipment that should **not** be started, used, or moved
- Identifies the starting point or power source for machinery

c. Federal safety orange

- Identifies dangerous parts of equipment that could cut, crush, shock, or otherwise injure
- Indicates safety starter buttons

d. Federal safety purple (or magenta or black on safety yellow)—Indicates radiation hazards

Information Sheet

e. Federal safety blue

- Identifies tags that indicate equipment that should **not** be started, used, or moved

f. Federal safety black and white

- Indicate traffic-flow paths
- Indicate storage areas
- Identify housekeeping equipment and its location

g. Federal safety green

- Identifies safety equipment other than fire-fighting equipment and its location
- Identifies first-aid equipment and its location

29. Electrical hazards in the electronics workplace

a. Live circuits—Work with electronic circuitry requires that those circuits sometimes be powered during testing and maintenance.

b. Exposed conductors—Although most conductors are insulated, terminals, connectors, and other components may have uninsulated conductors.

c. Capacitive components—Some electrical and electronic components store charge which can cause shock even when the equipment is not powered.

d. Accidental circuits—Circuits can be created through improper fabrication or maintenance or as the result of shorts and grounds that can energize conductors and components that the technician does not expect to be energized.

30. Electrical shock

a. Electrical shock is the result of the human body becoming a conductor for electricity.

b. Six major variables affect the damage that can occur as a result of electrical shock:

Information Sheet

- The amount of voltage

  Note: Voltages as low as 30 volts can be fatal and should be considered dangerous.

- The amount of current

  Note: Current is more critical than voltage in determining the amount of damage that electrical shock will cause. A person can feel a current of as little as 1 milliamp. Ten milliamps can cause physical damage and temporary paralysis in the victim. Electrical shocks of more than 100 milliamps are generally fatal if they last for more than one second.

- The body's level of electrical resistance

  Note: The human body normally offers about 500 Kohms resistance. However, if wet, that resistance may drop to as little as 300 ohms. Thus, if the body's electrical resistance drops, Ohm's Law shows that the net effect would be to raise the relative current level.

- The amount of time of exposure

- The entry site

- Individual differences in people

c. High voltage tends to knock the victim away from the circuit, reducing the time of exposure.

d. High current tends to paralyze the muscles, causing the victim to remain in contact with the circuit.

31. Treating victims of electrical shock

a. Remove the victim from the source of shock.

Note: If possible, turn off the electrical source or use a wooden-handled ax or insulated wire cutters to cut the live conductor. If that is not possible, use a nonconductor such as a **dry** stick, rope, leather belt, or blanket to break the contact between the victim and the electrical source.

b. Call for assistance.

Note: If assistance is available, you should have the most qualified person provide first-aid as described on the next page while someone else contacts a medical facility to request an ambulance or to arrange transport of the victim.

Information Sheet

c. Administer resuscitation if required and if properly trained.

Note: Electrical shock may cause the victim to stop breathing or may cause the victim's heart to stop beating. These conditions should be treated only by personnel trained in mouth-to-mouth and cardiopulmonary resuscitation (CPR).

d. Administer first-aid for traumatic shock by keeping the victim warm and comfortable and elevating the legs slightly.

Note: Traumatic shock is a condition in which life processes such as breathing, blood circulation, and other functions are impaired, often as the result of an injury. A person who survives electrical shock may go into traumatic shock.

e. Take precautions to protect burns by covering them lightly with sterile gauze if available or with clean cloths.

Note: Do not put water, ointments, salves, or other substances on the burns. Use care not to get dirt or contaminants in the burns or to breathe on them.

f. Continue to provide attention to the victim until professional medical assistance is available.

32. Chemical hazards in the electronics workplace

a. Irritants—Cause watery eyes, itchy skin, sneezing, or similar conditions that are not injurious but which may present safety hazards by being a distraction

Examples: Acetone, graphite powders, some acidic fumes

b. Caustics—Cause burns upon contact with the skin or body parts

Examples: Hydrochloric acid, harsh cleaning solutions

c. Immediate toxins—Cause death or destruction of organs within a short time after exposure

Examples: Alcohols, some solvents, some thinners and inks

d. Long-term toxins—Cause death or destruction of organs after frequent exposure over a period of time

Examples: Lead, solder

e. Carcinogens—Cause cancer, usually after long-term or excessive exposures

Examples: Caustic substances, alcohols, solvents, radioactive substances

f. Mutagens—May cause birth defects in the children of those suffering exposure

Example: Radioactive substances

33. Ways in which chemicals can enter the body

a. Ingestion—By mouth

b. Absorption—Through the skin

c. Inhalation—By breathing in vapors, gases, or fumes

34. Classes of fires

a. Class A—Ordinary combustible materials such as paper, wood, rags, and plastics

b. Class B—Flammable liquids and gases such as solvents, oil, paints, and inks

c. Class C—Live electrical equipment, such as computers, test equipment, electronic devices, and electrical wiring

d. Class D—Combustible metals such as iron, magnesium, sodium, and potassium

35. High energy hazards in the electronics workplace

a. High-intensity light—Can cause temporary or permanent blindness or burns from the heat produced

Examples: Lasers, component location light beams, bright lights

b. High-intensity sound waves—Can cause temporary or permanent deafness

Examples: Amplified sounds, high-frequency sounds

c. Electromagnetic waves—Can interfere with pace-makers and can lead to excessive vibration and heating of internal organs

Examples: Microwave transmitters, radar stations

d. Radiation waves and particles—Can cause burns and can lead to cancer and genetic defects in the offspring of victims

Examples: X-ray machines, radioactive substances used in some components, devices, coatings, and test procedures

Shop Orientation and Safety
Unit 2

Assignment Sheet 1— Interpret Material Safety Data Sheets

Name ______________________________ Overall Rating ____________

Evaluation criteria	**Rating**
• Directions have been followed	________
• Minimum of 85 percent of answers are correct	________
Note: Each correct answer is worth 3 points.	

Introduction: It is important for workers in today's electronics industry to understand the materials with which they work and the potential dangers that those materials represent. Further, they need to know how to reduce the risks of exposures to these materials and what to do if there is an accident or injury involving such substances. The worker's source of this type of information is the MSDS. This assignment sheet provides practice in how to read and interpret these important forms.

Directions: Your instructor will provide you with information on how to interpret MSDSs and sample MSDSs. Use the materials provided to answer the following questions. Write your answers on the blanks provided below each question.

MSDS 1

1. What is the name of this product?

   ____

2. What is the first hazardous ingredient listed?

   ____

3. What is the threshold limit value of the first listed ingredient?

   ____

4. Does the product contain any carcinogens? If so, which ones?

   ____

Assignment Sheet 1

5. What danger does this product present to the user's eyes?

6. What danger does this product present to the user's skin?

7. What danger does this product present to the user if ingredients are inhaled?

8. What precautions are recommended for handling the product (protective clothing, etc.)?

9. What is the recommended first-aid treatment if the eyes become contaminated with this product?

10. What is the recommended first-aid treatment if the skin becomes contaminated with this product?

11. Does the MSDS list any special fire or explosion hazards for this product? If so, what?

Assignment Sheet 1

12. What extinguishing agent should be applied to a fire involving this product?

    ____

13. Is the product stable? ______________________________

14. What hazardous by-products of decomposition are listed?

    ____

    ____

15. Under what conditions should the product be stored?

    ____

    ____

16. How should this product be disposed of?

    ____

    ____

MSDS 2

1. What is the name of this product?

   ____

2. What is the first hazardous ingredient listed?

   ____

3. What is the threshold limit value of the first listed ingredient?

   ____

4. Does the product contain any carcinogens? If so, which ones?

   ____

Assignment Sheet 1

5. What danger does this product present to the user's eyes?

____

____

6. What danger does this product present to the user's skin?

____

____

7. What danger does this product present to the user if ingredients are inhaled?

____

____

8. What precautions are recommended for handling the product (protective clothing, etc.)?

____

9. What is the recommended first-aid treatment if the eyes become contaminated with this product?

____

____

10. What is the recommended first-aid treatment if the skin becomes contaminated with this product?

____

____

11. Does the MSDS list any special fire or explosion hazards for this product? If so, what?

____

____

12. What extinguishing agent should be applied to a fire involving this product?

____

Assignment Sheet 1

13. Is the product stable? ______________________________

14. What hazardous by-products of decomposition are listed?

____

____

15. Under what conditions should the product be stored?

____

____

16. How should this product be disposed of?

____

____

Shop Orientation and Safety
Unit 2

Assignment Sheet 2— Interpret Safety Symbols and Colors

Name ______________________________ Overall Rating ____________

Evaluation criteria	**Rating**
• Directions have been followed	________
• Minimum of 80 percent of answers are correct	________
Note: Each correct answer is worth 10 points.	

Introduction: Electronic facilities and equipment are likely to be marked with symbols and colors intended to help technicians to do their job more safely. For such symbols to be effective, you must be able to recognize their meaning.

Directions: Read each of the following problems and answer the question that goes with each. Write an "X" beside the best choice in each group of possible answers.

1. A green box or white box marked with a green cross is most likely to contain what type of equipment?

_____a. A first-aid kit

_____b. A telephone for making emergency calls

_____c. A fire extinguisher for electrical fires

_____d. The main power cutoff switch for the facility

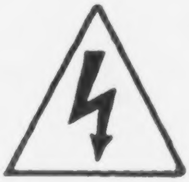
2. The symbol at the right is commonly used on electronic equipment. What type of hazard does it represent?

_____a. Possibility of lightning strike

_____b. Susceptibility to electrostatic discharge

_____c. Electrical hazards

_____d. Electromagnetic hazards



Assignment Sheet 2

3. You must dispose of some rags that have become contaminated with flammable solvent. In what color of container should you place the rags?

______a. Red

______b. Yellow

______c. Orange

______d. None of the above; rags can be disposed of in any available container

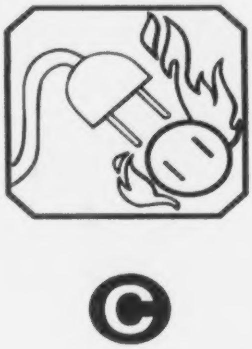
4. The symbol at the right appears on a fire extinguisher in your facility. Can that fire extinguisher be used to put out a fire in a computer?

______a. Yes

______b. Only if the equipment is turned off and unplugged first

______c. Only if the computer chassis housing is made of metal

______d. Not under any circumstances



(Blue)

5. While working in a facility, you find that some equipment does not have power even though it is turned on and plugged in. On checking the circuit breaker panel you find that the circuit breaker serving the equipment is off and that a blue tag is hanging on it. What should you do?

______a. Remove the tag and reset the circuit breaker

______b. Check to see if anyone is working on the equipment and if you find no one in the immediate area working on the equipment, remove the tag and reset the circuit breaker

______c. Move the equipment to another location and use it there

______d. Do not use the equipment

Assignment Sheet 2

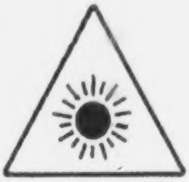
6. The symbol at the right may appear on electronic equipment. What type of hazard does it represent?

______a. Laser or high-intensity light hazards

______b. Radioactive hazards

______c. Electrical hazards

______d. Electromagnetic hazards



7. On the wall near a facility's wave soldering machine is a red button. What is the most likely purpose of that button?

______a. To sound the fire alarm

______b. To activate the fire sprinkler system

______c. To start the wave soldering machine in an emergency

______d. To shut down the wave soldering machine in an emergency

8. An electronics manufacturing facility has black and white striped tape on the floor. What does the tape indicate?

______a. Traffic-flow path

______b. Areas to be cleaned during normal maintenance service

______c. Emergency evacuation routes

______d. Paths to fire extinguishers

9. In one area of your facility there is a low beam in a hallway to a maintenance closet. What safety color should the beam be painted to indicate the hazard?

______a. Red

______b. Yellow

______c. Orange

______d. None of the above; safety colors are not required for hazards above waist-high levels

Assignment Sheet 2

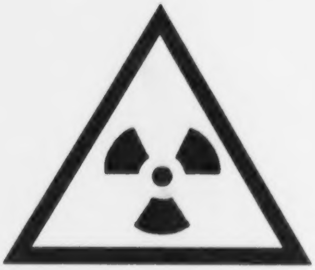
10. An electronics research lab has a cabinet on the front of which is a large purple square and the symbol shown at the right. What is probably stored in this cabinet?

______a. Flammable materials

______b. Biological hazards

______c. Housekeeping equipment

______d. Radioactive materials



Shop Orientation and Safety
Unit 2

Assignment Sheet 3— Determine Basic First-aid Measures for Emergency Situations

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
• Directions have been followed	________
• Answers indicate a cognitive grasp of unit information and critical thinking	________

Introduction: Because of the potential dangers that exist in the electronics industry and in every-day living, the chances are good that you will someday be present when a situation requires the use of proper safety or first-aid procedures. Based on the information provided in this unit of instruction and other information that your instructor may have provided, this assignment sheet will allow you to analyze emergency situations and determine the proper course of action or to critique the actions of others.

Directions: Read the following scenarios and answer the questions accompanying each.

1. A co-worker has rested his arm against a hot transformer, resulting in a burn. The area of his arm that contacted the transformer is red and several small blisters have formed. You have a first aid kit which contains gauze, large bandages, tape, and several medicines, including an ointment for burns. What should you do to treat your co-worker's injury?

Assignment Sheet 3

2. An electronics technician has come into contact with a live circuit. The voltage and current were low, and there is no apparent injury, such as a burn. She says that she feels fine, except for a little tingling sensation in her fingers. She insists on going back to work and does so. However, a few minutes later, you look at her and notice that she seems pale. You ask her if she feels okay, and she replies, "Yeah, just a little weak is all. And I can't seem to remember where I put my multimeter." Do you think that she has a problem? If so, what is it and what should be done?

____

____

____

3. A group of four people is working at a cellular telephone relay station about eight miles from the nearest town with a hospital. Their truck is equipped with a cellular telephone. The crew's supervisor knows CPR. One of the crew members falls from the tower and lies on the ground, unconscious and not breathing. What should the other three team members do in this situation?

Supervisor: ______________________________

____

____

Crew member 1: ______________________________

____

Crew member 2: ______________________________

____

4. A worker in your shop accidentally touches a wrench to a live circuit. He falls to the floor but is still in contact with the circuit. What is the first thing that you should do?

____

____

There is one other worker in the area but neither of you know CPR. What should you do next?

____

____

Assignment Sheet 3

It is decided that you will take care of the victim. What ABCs should you apply?

____

____

You find that the victim does not appear to be breathing and that his tongue is severely swollen. What should you do?

____

____

The victim begins breathing. His heart is beating and he has a pulse. What should you do to reduce the risk of traumatic shock?

____

____

As you continue examining the victim, you find that the wrench he was using is still in his hand. The hand is swollen and covered with red blotches. Several blisters cover the area around the wrench. The flesh immediately around the wrench is charred and the wrench appears to be stuck to the flesh. Should you try removing the wrench and how should you treat the burns?

____

____

The victim gains consciousness before paramedics arrive. He says that now that he can move, he thinks that you should help him to a car and drive him to the hospital. How would you respond?

____

____

The victim says that there is pain in his left leg. You find that there is a wound that looks slightly burned and which is bleeding, though not severely. You suspect that this may be the exit wound for the electricity or that the victim injured his leg on some equipment when he received the shock or when he fell. What should you do about the wound?

____

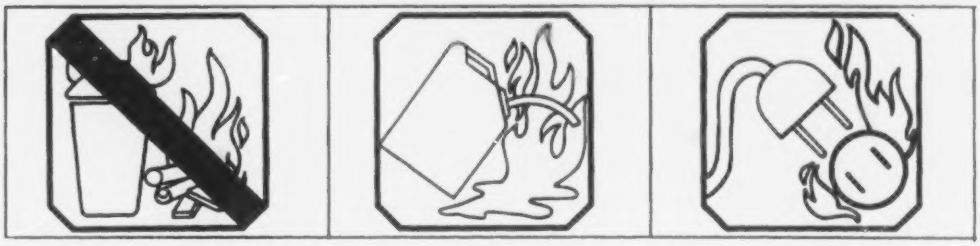
____

Assignment Sheet 3

5. A co-worker is using paint remover to clean up an electronic equipment rack. Suddenly there is a flash, and you look over to see that the equipment rack, which contains live equipment is on fire. Immediately the flames spread to your co-worker and her shirt catches on fire. What should you do first?

The co-worker begins running around wildly and screaming. What should you do?

You manage to help the co-worker get the fire on her clothing out and to calm down, but she is still too upset to be of much help. There is a fire extinguisher marked with the following symbols. Can you use it on the fire? If so, how should it be applied?



The victim's arm is red and covered with blisters. She says that it hurts a lot and asks you to do something to make it stop hurting. How should you treat the burns?

Shop Orientation and Safety
Unit 2

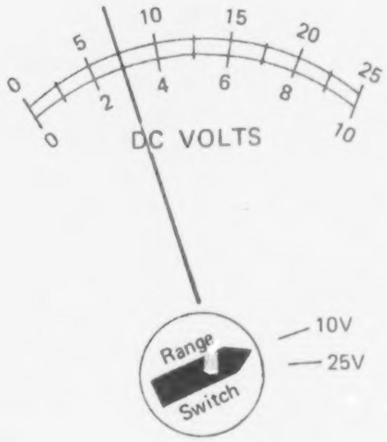
Assignment Sheet 4— Interpret Meter Readings

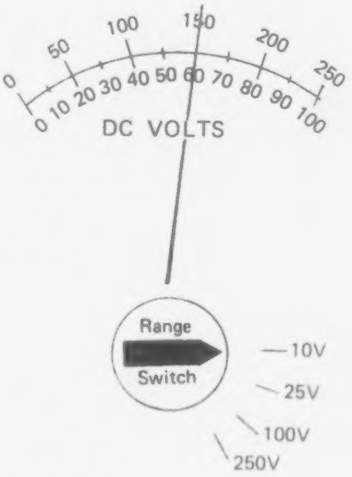
Name ______________________________ Overall Rating ____________

Evaluation criteria	**Rating**
• Directions have been followed	________
• Minimum of 80 percent of answers are correct	________
Note: Each correct answer is worth 10 points.	

Introduction: As an electronics technician, you will frequently use various types of meters to measure electrical characteristics. To be successful, you will have to be able to interpret meter readings correctly. This takes practice because there are numerous types of meters and even meters of the same type can be configured in different ways so that the meter indication for one setting will mean something different at another setting. This assignment sheet will allow you to practice interpreting the readings of various types of meters.

Directions: Study the drawings below and on the following pages. On the space below each drawing, write the value of the reading shown. Be sure to include the unit of measure for your readings.

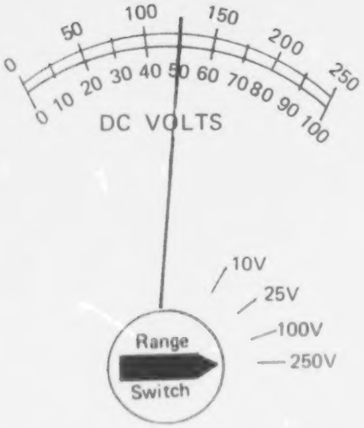

0
5
10
15
20
25
0
2
4
6
8
10
DC VOLTS
Range
Switch
10V
25V

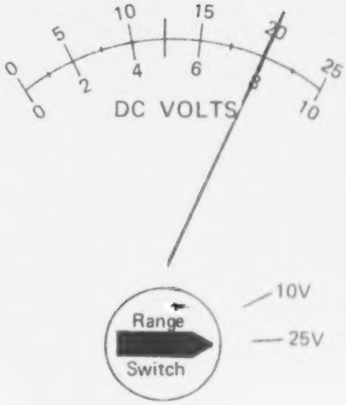

0
50
100
150
200
250
0
10
20
30
40
50
60
70
80
90
100
DC VOLTS
Range
Switch
10V
25V
100V
250V

1. ______________________________

2. ______________________________

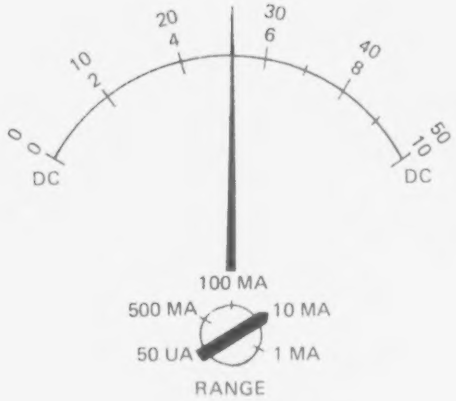
Assignment Sheet 4

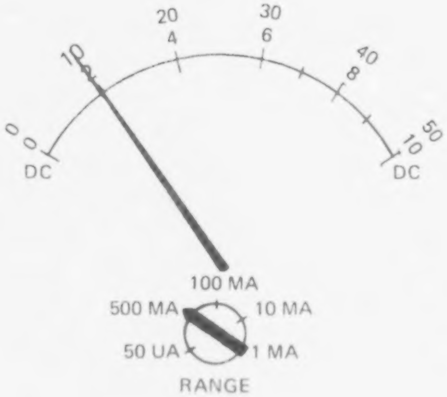

0
50
100
150
200
250
0
10
20
30
40
50
60
70
80
90
100
DC VOLTS
10V
25V
100V
250V
Range
Switch


0
5
10
15
20
25
0
2
4
6
8
10
DC VOLTS
10V
25V
Range
Switch

3. ________________________

4. ________________________

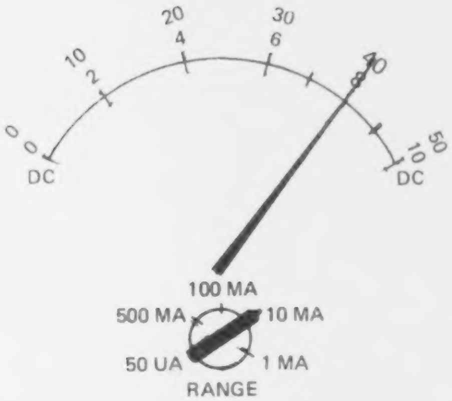

0
0
10
2
20
4
30
6
40
8
50
10
DC
DC
100 MA
500 MA
10 MA
50 UA
1 MA
RANGE

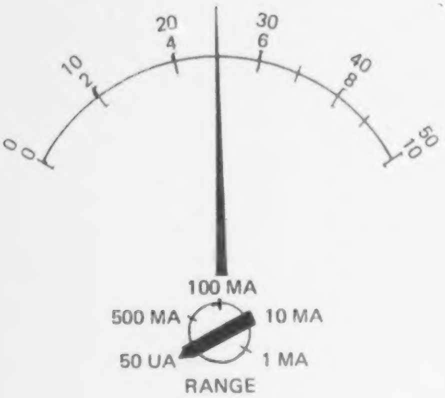

0
0
10
2
20
4
30
6
40
8
50
10
DC
DC
100 MA
500 MA
10 MA
50 UA
1 MA
RANGE

5. ________________________

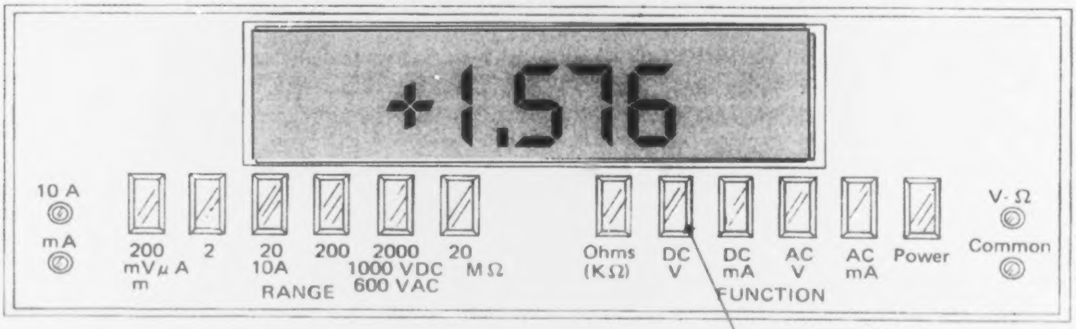
6. ________________________

Assignment Sheet 4


0
0
DC
10
2
20
4
30
6
40
8
50
10
DC
100 MA
500 MA
10 MA
50 UA
1 MA
RANGE


0
0
10
2
20
4
30
6
40
8
50
10
100 MA
500 MA
10 MA
50 UA
1 MA
RANGE

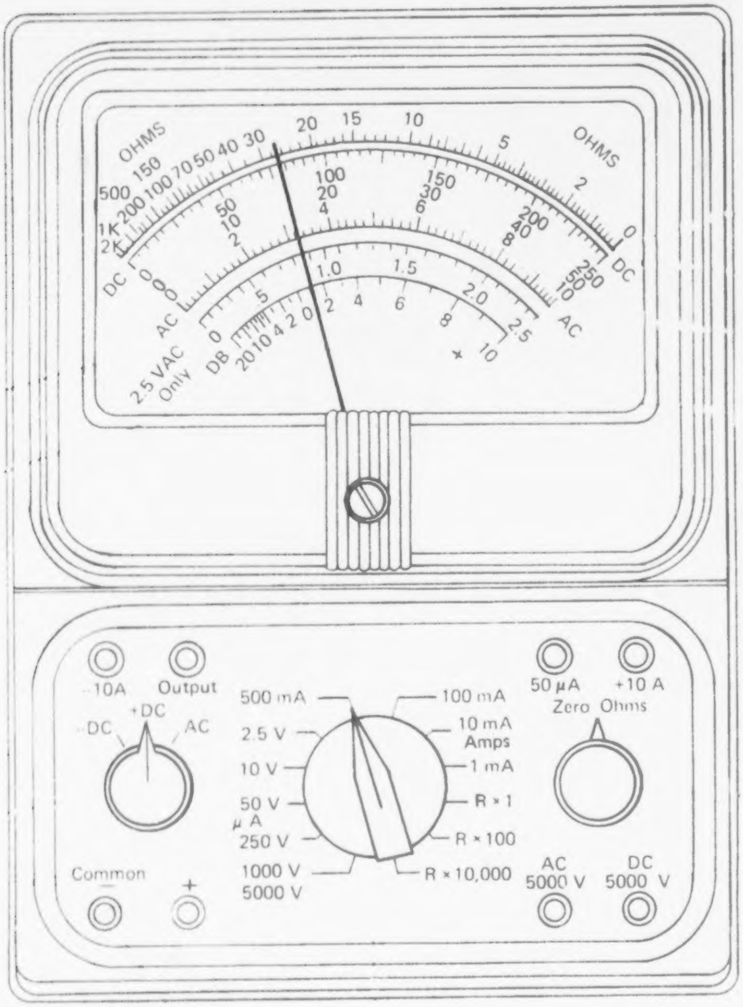
7. ______________________________ 8. ______________________________


+1.576
10 A
mA
200
mVμA
m
2
20
10A
200
2000
1000 VDC
600 VAC
20
MΩ
RANGE
Ohms
(KΩ)
DC
V
DC
mA
AC
V
AC
mA
Power
FUNCTION
V·Ω
Common

This button is depressed.

9. ______________________________

Assignment Sheet 4


OHMS
500 150 200 100 70 50 40 30 20 15 10 5
OHMS
2
0
1K
2K
100 20 4
150 30 6
200 40 8
250 50 10
50 10 2
DC
DC
AC
AC
1.0 1.5 2.0 2.5
0 5
2 4 6 8 10
2.5 VAC Only
DB
20 10 4 2 0
-10A
Output
-DC
+DC
AC
500 mA
2.5 V
10 V
50 V
μA
250 V
1000 V
5000 V
100 mA
10 mA
Amps
1 mA
R × 1
R × 100
R × 10,000
50 μA
+10 A
Zero Ohms
Common
−
+
AC
5000 V
DC
5000 V

10. ______________________________

Shop Orientation and Safety
Unit 2

Assignment Sheet 5—Calculate Voltage from Sine Wave Dimensions

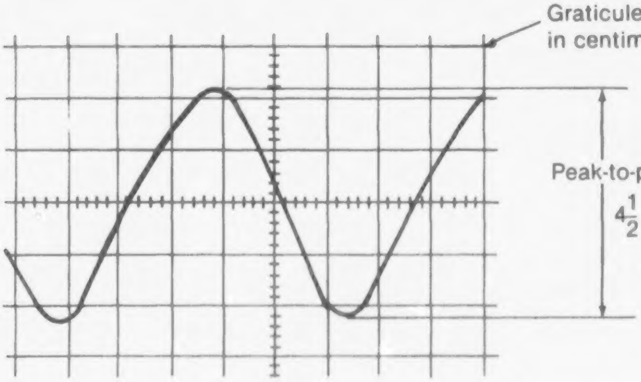
Name ______________________________ Overall Rating ____________

Evaluation criteria	Rating
• Directions have been followed	________
• Minimum of 75 percent of answers are correct	________

Note: Each correct answer is worth 25 points.

Introduction: An oscilloscope can be used to measure voltage by calculating root-mean-square (RMS). The following steps can be used to make this calculation.

Step 1: Determine the peak-to-peak value. Multiply the number of graticule markings by the volts/cm setting to determine the peak-to-peak voltage.



Graticule markings are in centimeters.

Peak-to-peak measures $4\frac{1}{2}$ centimeters or, $4\frac{1}{2}$ cm, peak-to-peak

Example: In the display above, the peak-to-peak measurement is 4.5 cm graticules. If the oscilloscope is set at 2 volts/cm, then the peak-to-peak voltage is:

4.5 cm x 2 volts/cm = 9 volts peak-to-peak

Step 2: Determine the peak voltage. Peak voltage is one-half of the peak-to-peak voltage. Thus, in the example peak voltage would equal:

Example: $\frac{\text{9 volts peak-to-peak}}{2}$ = 4.5 volts peak voltage

Assignment Sheet 5

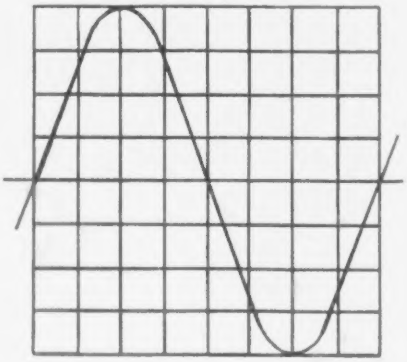
Step 3: Convert peak voltage to rms by multiplying by 0.707.

Example: 4.5 volts x 0.707 = 3.18 volts rms

Directions: Study the waveforms shown below. They represent displays on oscilloscopes configured as described. For each display, calculate the rms voltage. Write your answers on the blanks provided below each question.

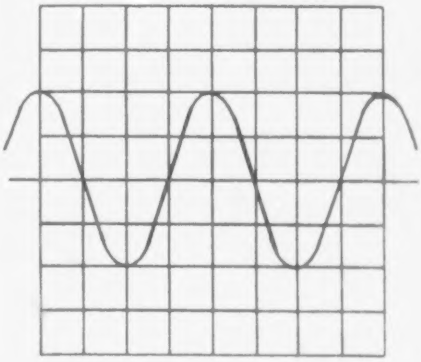
1. An oscilloscope is set at 2 volts/cm with a 10 x probe. The display below is produced. What is the voltage?

____



2. With a 1 x probe and the volts/cm set at 0.05, an oscilloscope produces the waveform shown below. What is the voltage?

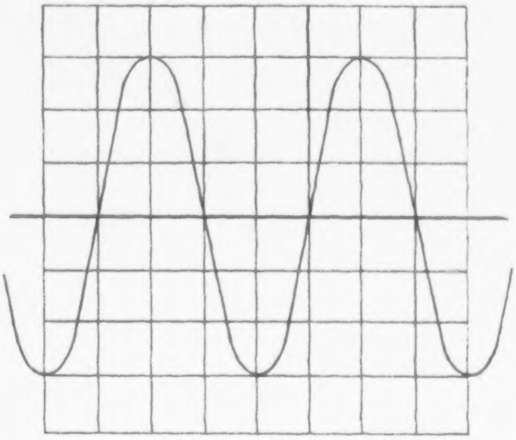
____



Assignment Sheet 5

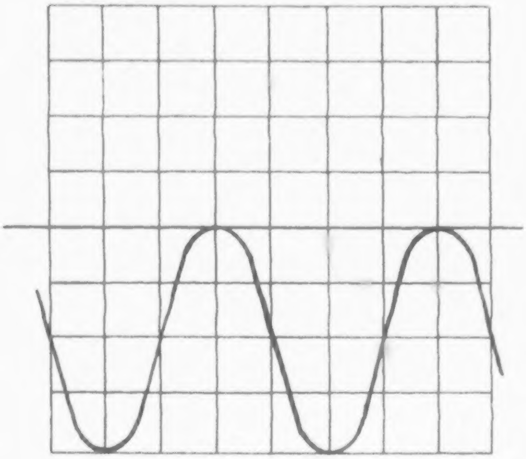
3. The waveform below was produced on an oscilloscope with a setting of 0.5 volts/cm and a 10 x probe. What is the voltage?

____



4. What is the voltage if the waveform below was produced on an oscilloscope using a 1 x probe and a 20 volts/cm setting?

____



Shop Orientation and Safety
Unit 2

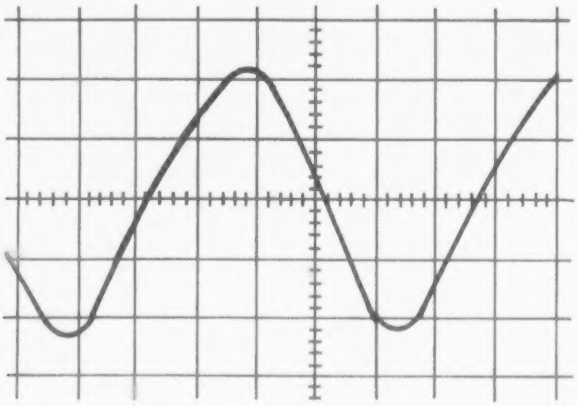
Assignment Sheet 6—Calculate Time and Frequency from Waveform Dimensions

Name ______________________________ Overall Rating ____________

Evaluation criteria	Rating
• Directions have been followed	________
• Minimum of 88 percent of answers are correct	________

Note: Each correct answer is worth 12 points.

Introduction: An oscilloscope display shows the length of time for signal cycles. This time can be used to determine signal frequency in Hertz. The following examples show how to calculate time and frequency.



Step 1: To calculate time, determine the number of graticule segments in the cycle. Then multiply that number by the sweep setting of the oscilloscope.

Example: In the display above, the cycle length is 5.5 centimeters. If the sweep setting is 5 ms/cm, then the cycle time would be:

5.5 cm x 5 ms/cm = 27.5 ms

Step 2: To calculate frequency, use the formula for frequency ($f = 1/t$) with time expressed in seconds.

Example: For the above waveform, convert the time to seconds and then calculate the frequency by using the formula:

$f = 1/t = 1/0.0275 = 36.36$ Hz

Assignment Sheet 6

Directions: Study the waveforms shown below. They represent displays on oscilloscopes configured as described. For each display, calculate the time and frequency of the waveform. Write your answers on the blanks provided below each question.

Note: Make sure that your answers agree with the units of measurement given for each problem.

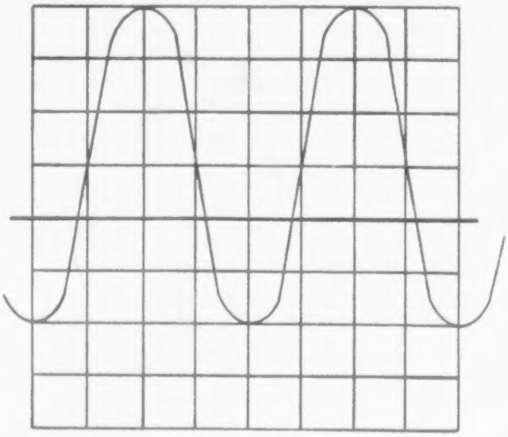
1. An oscilloscope is set at 2 μs/cm. The display below is produced.

What is the time?

______________________ s

What is the frequency?

______________________ MHz



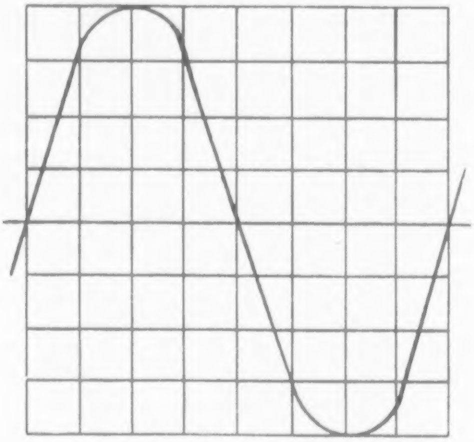
2. With the sweep set at 1 ms/cm, an oscilloscope produces the waveform shown below.

What is the time?

______________________ s

What is the frequency?

______________________ MHz



Assignment Sheet 6

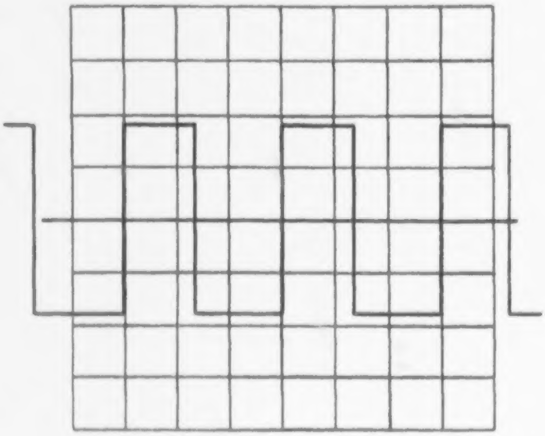
3. The waveform below was produced on an oscilloscope with a sweep setting of 1 s/cm.

What is the time?

_________________________ s

What is the frequency?

_________________________ MHz



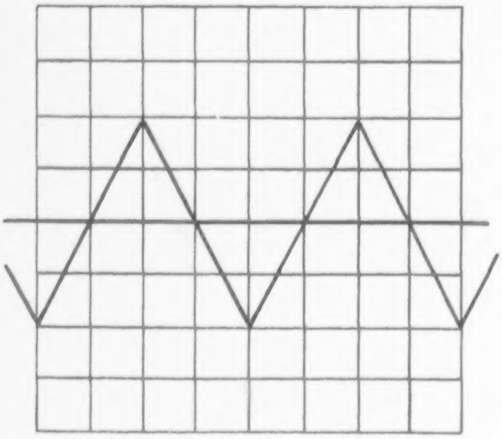
4. If the waveform below was produced on an oscilloscope using a sweep setting of 0.2 ms/cm,

What is the time?

_________________________ s

What is the frequency?

_________________________ MHz



Shop Orientation and Safety
Unit 2

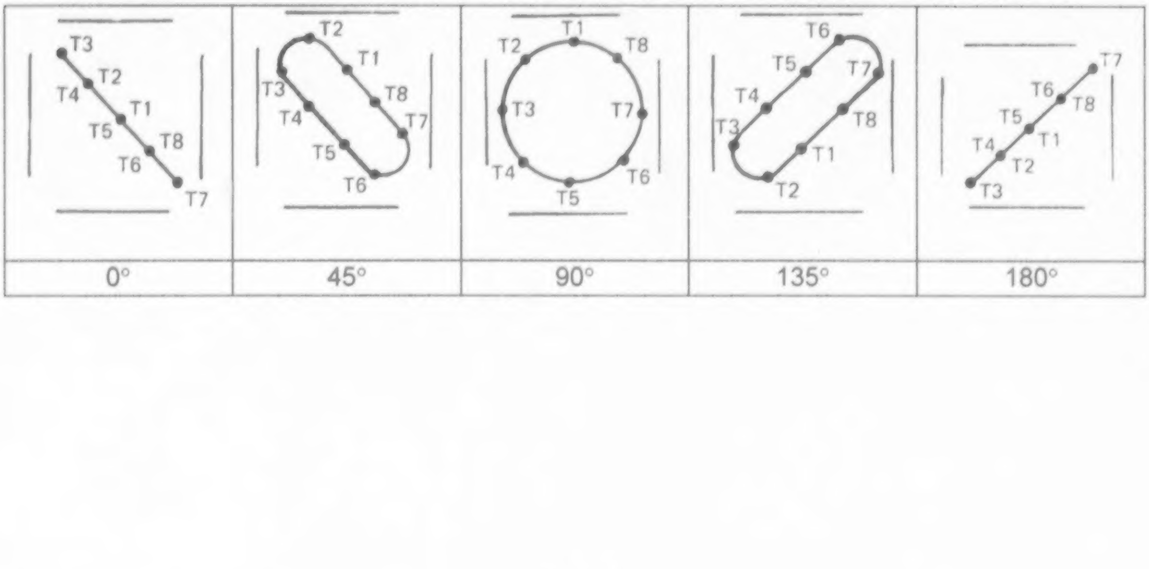
Assignment Sheet 7—Determine Phase Relationships of AC Signals

Name ______________________________ Overall Rating ____________

Evaluation criteria	**Rating**
• Directions have been followed	________
• Minimum of 82 percent of answers are correct	________
Note: Each correct answer is worth 18 points.	

Introduction: One way of comparing two signals is to determine whether they are *in phase* with each other. Two signals that are in phase have the same cycle length with corresponding points of the waveform occurring at the same time. The phase relationship of waveforms is measured in degrees with the maximum difference between two signals being 180° out of phase (one-half of a 360° cycle). This is represented by one signal peaking high at the same time the other signaling is peaking low.

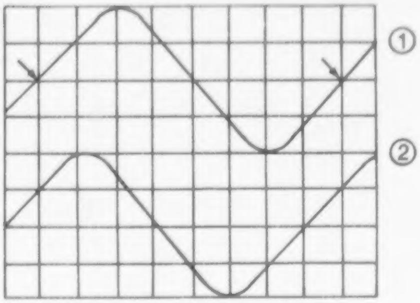
There are two ways of using an oscilloscope to determine the phase relationship of two signals. The first way is to calculate the difference based on the cycle length on the display, as explained below. The second method is to display the signals on the oscilloscope as *lissajous patterns*. Lissajous patterns are a set of five geometric figures that represent the phase relationship of two signals:



Assignment Sheet 7

To compute phasing from an oscilloscope display of both signals, first determine the cycle length. In the example below, the cycle is 8 cm. Since a full cycle is 360°, you can determine the number of degrees represented by one graticule line by dividing 360° by the number of lines in the cycle. Thus, in the example, each graticule line represents:

360° ÷ 8 = 45° per graticule line



One cycle = 8 cm
1 cm = 45°

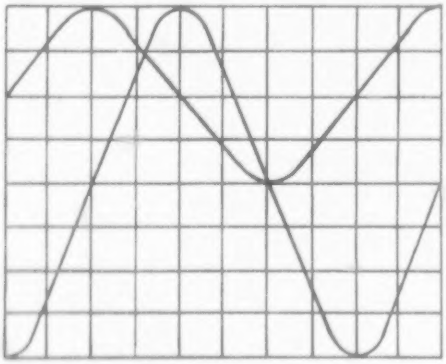
Phase difference = #cm × 45°
1 cm × 45° = 45°

Next, determine the distance between two corresponding points in the two signals. For example, compare the top amplitude point of the two signals. In our example display, the peak amplitudes occur one graticule line apart. To determine phasing, multiply the number of graticule lines that separate the corresponding parts of the two signals by the number of degrees represented by each graticule line. Continuing with the example, we computed that each graticule line represents 45°, so the phase difference between the signals equals:

1 graticule line x 45° = 45° out of phase

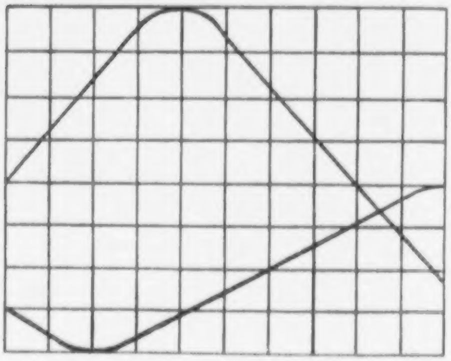
Directions: Study the oscilloscope displays below and on the pages that follow. Use lissajous phase patterns or calculate the phase shift as appropriate to determine how many degrees out of phase the signals are. Write your answers in the spaces provided with each display.

1. ______________ degrees out of phase

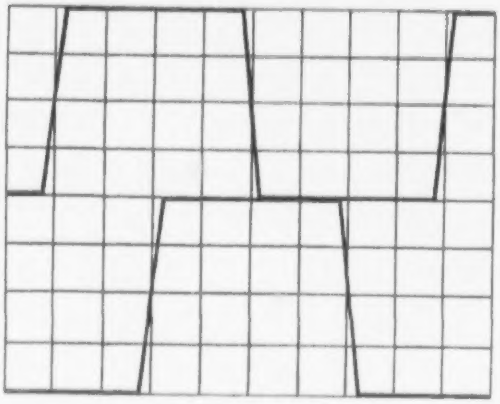


Assignment Sheet 7

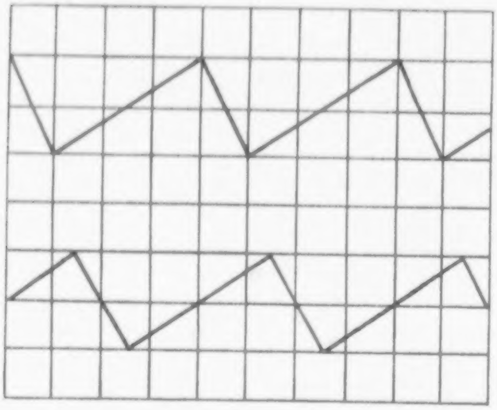
2. _______________ degrees out of phase



3. _______________ degrees out of phase

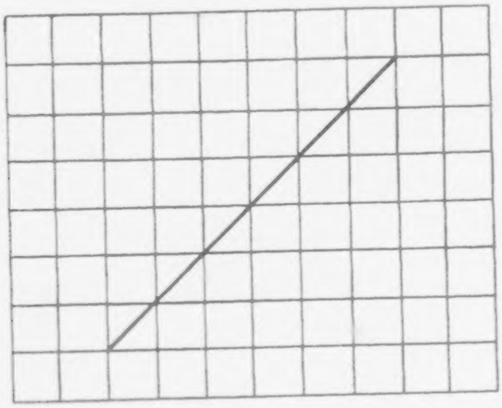


4. _______________ degrees out of phase

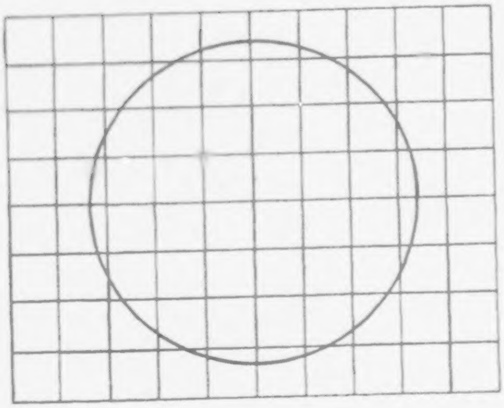


Assignment Sheet 7

5. _______________ degrees out of phase based on lissajous pattern



6. _______________ degrees out of phase based on lissajous pattern



Shop Orientation and Safety
Unit 2

Job Sheet 1—Lift and Move a Heavy Object

Name ______________________________ Attempt Number __________

Date ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
• Load was safely lifted	______
• Load was safely carried and set down	______

Introduction: The number-one worker injury in America today is back strain or injury. Most of these injuries come from trying to lift an object that is too heavy or from lifting an object improperly. It is very important, therefore, that you learn to assess the weight of a load to be lifted, and either get help to lift the load or lift the load properly, using your leg muscles, not your back.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Large, heavy box
- Gloves
- Lower-back support belt

B. Procedure

☐ 1. Put on gloves and lower-back support belt.

☐ 2. Size up the load.

☐ 3. Place your feet close to the object and 8 to 12 inches apart for good balance.

☐ 4. Bend your knees to a degree that is comfortable.

☐ 5. Grip the box firmly with both hands.

☐ 6. Keeping your back straight and using your leg muscles, lift the box to waist height and hold it close to your body.

> **Caution: Do not make any turning or twisting motions until the lift is complete.**

☐ 7. Turn by changing foot position, making sure that your path is clear.

☐ 8. Carry the box to the new location, using a normal walking gait and keeping your view unobstructed.

☐ 9. Reverse the lifting procedure to set the box down, taking care to bend your knees, keep your back straight, and avoid setting the box on your fingers or feet.

Evaluator's comments: ______________________________

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____

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Shop Orientation and Safety
Unit 2

Job Sheet 2—Operate a Fire Extinguisher

Name ______________________ Attempt Number __________

Date ______________________ Overall Rating __________

Evaluation criteria	**Rating**
• Extinguisher was carried properly	________
• User was within stream reach of fire	________
• P-A-S-S sequence was followed	________
• Fire was completely extinguished	________

Introduction: Using a portable fire extinguisher properly requires more than simple manipulation. You must always size up the fire and decide whether it can be extinguished with an extinguisher. If the fire is too large or too smoky, call the fire department. If the fire is small enough to be extinguished with an extinguisher, always fight it with your back to a means of escape.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Portable fire extinguisher suitable for a Class A fire
- **Small** Class A fire in clear, safe area
- Charged hose (hose hooked up to a water source and with water in the hose) or another secondary means of extinguishment for backup

> **Caution: This procedure should only be performed outdoors on a windless day and only under the direct supervision of your instructor.**

B. Procedure

☐ 1. Pick up the fire extinguisher by its handle.

Note: All modern fire extinguishers are designed to be used in an **upright** position.

Job Sheet 2

☐ 2. Read the fire extinguisher label to determine proper stream reach.

Note: *Stream reach* is the distance the extinguishing agent is propelled. Stream reach varies with extinguisher, and may range from 3 to over 20 feet. Normally, the smaller the extinguisher, the shorter the stream reach.

☐ 3. Walk—do not run—to within stream reach of the fire.

☐ 4. **Pull** the pin at the top that keeps the handle from being pressed accidentally; **pull** the nozzle free from its clip.

Note: The inspection band or wire should break automatically when the pin is pulled.

☐ 5. **Aim** the nozzle at the fire.

☐ 6. **Squeeze** the discharge handle to release the extinguishing agent.

Note: Release the handle as required to stop the flow of extinguishing agent.

☐ 7. **Sweep** the nozzle back and forth at the base of the flames.

☐ 8. After the fire appears to be out, probe for remaining hot spots.

☐ 9. Make sure that the fire is out by extinguishing any hot spots.

Evaluator's comments: ______________________________

____

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Shop Orientation and Safety
Unit 2

Job Sheet 3—Handle and Store Flammable Materials and Toxic Substances

Name ______________________ Attempt Number ____________

Date ______________________ Overall Rating ____________

Evaluation criteria	**Rating**
• Material was properly handled	________
• Material was properly stored	________
• Material was properly disposed of as required	________

Introduction: Electronic technicians are required to work with a number of substances that are flammable and some that can be harmful (see Objective 23). Technicians must use care not only to protect themselves when using such substances but also to protect others who may be working in the area or who may use the substances after them and even those who may be exposed to the substances outside of the facility, such as through an accidental release of the substance into the air or into a water system.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Material to be handled or stored
- Material Safety Data Sheet for material to be handled or stored
- Proper equipment for handling and storing material as specified by label or MSDS

B. Procedure

☐ 1. Identify material to be handled or stored.

☐ 2. Obtain and review MSDS for the material to be handled or stored.

☐ 3. Obtain any special equipment or arrange for proper use or storage facilities.

Examples: Rubber gloves, well-ventilated area

Job Sheet 3

☐ 4. Identify location of safety apparatus required to support procedure.

Examples: Appropriate fire extinguishers for flammable materials, adequately equipped first aid kits in the event of exposure, eye wash stations

☐ 5. Approach the material storage area cautiously using various senses to check for signs of leaks, damage, or other defects.

Examples: **Look** for signs of corrosion or rust, **listen** for hissing or dripping sounds, **smell** for unusual odors, **cautiously feel** for unusual temperatures and container damage

☐ 6. Examine the material container to ensure that it is a proper container for the material and that it is properly labeled.

☐ 7. Review the label instructions and comply with them in addition to the MSDS requirements.

☐ 8. Check for an expiration date and verify that the product's shelf life has not been exceeded.

Note: Some products have both a *shelf life* and a *use life*. The shelf life refers to how long the product is acceptable for use. If the label also provides a use life, that refers to the time that the product can be used after it is opened or mixed.

☐ 9. Follow the MSDS and label instructions for using the product as well as the procedures for its use in your facility.

☐ 10. Return usable unused product to a proper container and store in accordance with MSDS and label directions and policies in your facility.

☐ 11. Clean up any spilled materials.

☐ 12. Properly dispose of any unusable or out-of-date product and any contaminated materials, such as papers and rags.

Note: The disposal of many substances is regulated by federal, state, and local laws. Many facilities contract with licensed disposal services to handle this task. If your facility uses such a service, it may be necessary to temporarily store the product requiring disposal and notify the disposal service. Also, some organizations have special storage requirements for contaminated items, such as rags, clothing, equipment, etc. Follow your facility's policies for storage and disposal of waste, contaminated, and out-of-date articles.

Job Sheet 3

Evaluator's comments: ____

____

____

____

Shop Orientation and Safety
Unit 2

Job Sheet 4—Obtain Tools from the Tool Crib

Name ______________________ Attempt Number __________

Date ______________________ Overall Rating __________

Evaluation criteria	**Rating**
• Proper tool was obtained	______
• Facility policies and procedures were followed	______

Introduction: Electronics technicians in all areas of the industry are required to use tools. Designers build prototype equipment. Fabrication and repair specialists use tools to build and service electronic equipment. Even sales personnel use tools to set up displays, assemble products, and demonstrate equipment. Therefore, an electronics technician must know how to use the tools of the trade. In many organizations, tool cribs or tool rooms are responsible for maintaining tools and for issuing them to technicians who need to use them.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Tool list
- Facility tool issue procedures

B. Procedure

☐ 1. Determine tools to be obtained.

☐ 2. Present tool list to tool crib attendant or select tools per your facility's procedures.

☐ 3. Inspect selected tools to ensure that they are in good operating condition and free from defects; if a tool requires calibration or periodic service, verify that the calibration or service is current.

☐ 4. Follow facility procedures for signing out tools.

Job Sheet 4

☐ 5. Use tools as required, following all safety and use guidelines.

Note: In most facilities, technicians are allowed to use only those tools for which they have been trained to use. In some cases, use of a tool or equipment may require special training and even certification that a technician is qualified to use the tool.

☐ 6. When done, clean each tool and inspect it to verify that it is suitable for use by the next person:

- Clean
- Free from damage
- Selectable settings are normally configured
- Serviced as required
- Securely assembled

☐ 7. Return tools to tool crib and acknowledge return per facility procedures.

Evaluator's comments: ____

____

____

____

Shop Orientation and Safety
Unit 2

Job Sheet 5—Measure Electrical Characteristics in a Series Circuit

Name ______________________________ Attempt Number ____________

Date ______________________________ Overall Rating ____________

Evaluation criteria	**Rating**
• Correct procedures were followed	______
• Equipment was configured correctly	______
• Equipment was used correctly	______
• Correct readings were obtained	______

Introduction: An electronics technician must understand how electrical circuits work and must be able to measure the electrical characteristics of a circuit to determine if it is working correctly. A number of different instruments can be used to take the required readings, and the competent technician knows how and when to use each.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Note: This job sheet describes the use of various types of test equipment to measure electrical characteristics in a series circuit. Depending on the equipment used in your facility, you may or may not complete all sections of this job sheet.

A. Equipment and materials

- Voltmeter
- Ammeter
- Ohmmeter
- Multimeter
- Series circuit with adjustable power supply or various voltages of batteries

B. Procedure to measure voltage with a voltmeter

☐ 1. Set the power supply to 6 volts (or use a 6-volt battery or combination of batteries).

☐ 2. Energize the circuit.

Job Sheet 5

☐ 3. Ensure that the voltmeter is set for DC measurements and a scale that is appropriate to the expected voltage.

☐ 4. Touch the red (+) probe of the voltmeter to the positive terminal of the power source.

Caution: Voltmeters must be connected with the same polarity as the circuit or damage to the meter may occur.

☐ 5. Touch the black (-) probe to the negative terminal of the power source.

☐ 6. Read the meter and record your reading.

Note: The meter reading shows the difference in voltage levels between the two points. In this case, the voltage should be approximately the same as the setting of the power supply.

☐ 7. While keeping the positive probe on the positive terminal of the power source, move the black probe to touch an exposed conductor on the positive side of the load.

☐ 8. Read the meter and record your reading.

Note: The meter reading shows the potential difference between the power source and that point in the circuit.

☐ 9. While keeping the positive probe on the positive terminal of the power source, move the black probe to touch an exposed conductor on the negative side of the load.

☐ 10. Read the meter and record your reading.

Note: The difference in the reading at Step 8 and Step 10 is the amount of voltage drop across the load.

☐ 11. Place the positive probe on the positive side of the load and the negative probe on the negative side of the load.

☐ 12. Read the meter and record your reading.

☐ 13. Discuss your results with your instructor.

☐ 14. Remove power from the circuit.

☐ 15. Return equipment and materials to their proper storage area.

Job Sheet 5

C. Procedure to measure current with an ammeter

☐ 1. Set the power supply to 1.5 volts or install a 1.5-volt battery.

☐ 2. Disconnect the negative terminal of the circuit.

☐ 3. Touch the black probe of the ammeter to the negative terminal of the **circuit** and the red probe to the negative terminal of the **power source**.

☐ 4. Energize the circuit.

☐ 5. Read the meter and record your reading.

☐ 6. Open the circuit switch.

☐ 7. Reconnect the negative terminal of the circuit to the negative terminal of the power supply.

☐ 8. Touch the black probe of the ammeter to the negative side of the switch and the red probe to the positive side of the switch.

Note: This should complete a series circuit around the switch with the switch open.

☐ 9. Read the meter and record your reading.

☐ 10. Repeat Steps 1-9 with the power supply set to 3.0 volts or using two 1.5-volt cells.

☐ 11. Discuss your results with your instructor.

☐ 12. Remove power from the circuit.

☐ 13. Return equipment and materials to their proper storage area.

D. Procedure to measure resistance with an ohmmeter

☐ 1. Ensure that circuit power is off.

Caution: Never connect an ohmmeter to a circuit that is energized or energize a circuit to which an ohmmeter is connected.

☐ 2. Ensure that the circuit switch is open.

Job Sheet 5

☐ 3. Isolate the component or branch for which resistance is to be measured from the circuit by disconnecting at least one circuit connection.

Note: For example, if you want to measure the resistance of a lamp, disconnect one circuit connection. The more completely the circuit segment can be isolated, the more accurate will be the reading.

☐ 4. Touch one probe of the ohmmeter to one end of the segment or component to be tested and the other probe to the other end.

☐ 5. Apply power to the ohmmeter.

Note: Ohmmeters provide their own power source. Some apply power as soon as the circuit is completed, some have on-off switches, and others use different designs to provide power application.

☐ 6. Read the meter and record your reading.

☐ 7. Discuss your results with your instructor.

☐ 8. Return the circuit to its original configuration.

☐ 9. Return equipment and materials to their proper storage area.

E. Procedure to measure electrical characteristics with a multimeter

☐ 1. Configure the multimeter to measure voltage.

☐ 2. Set the range setting to a range value suitable for the circuit to be measured.

☐ 3. Perform Procedure B, Steps 1-13 using the multimeter.

☐ 4. Configure the multimeter to measure current.

☐ 5. Set the range setting to a value suitable for the circuit to be measured.

☐ 6. Perform Procedure C, Steps 1-11 using the multimeter.

☐ 7. Configure the multimeter to measure resistance.

☐ 8. Set the range setting to a range value suitable for the circuit to be measured.

☐ 9. Perform Procedure D, Steps 1-9 using the multimeter.

Job Sheet 5

Evaluator's comments: ____

Shop Orientation and Safety
Unit 2

Job Sheet 6—Measure Electrical Characteristics in a Parallel Circuit

Name ______________________________ Attempt Number __________

Date ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
• Correct procedures were followed	______
• Equipment was configured correctly	______
• Equipment was used correctly	______
• Correct readings were obtained	______

Introduction: An electronics technician must understand how electrical circuits work and must be able to measure the electrical characteristics of a circuit to determine if it is working correctly. A number of different instruments can be used to take the required readings, and the competent technician knows how and when to use each.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Note: This job sheet describes the use of various types of test equipment to measure electrical characteristics in a parallel circuit. Depending on the equipment used in your facility, you may or may not complete all sections of this job sheet.

A. Equipment and materials

- Voltmeter
- Ammeter
- Ohmmeter
- Multimeter
- Parallel circuit with adjustable power supply or various voltages of batteries

B. Procedure to measure voltage with a voltmeter

☐ 1. Set the power supply to 6 volts (or use a 6-volt battery or combination of batteries).

☐ 2. Energize the circuit.

Job Sheet 6

☐ 3. Ensure that the voltmeter is set for DC measurements and a scale that is appropriate to the expected voltage.

☐ 4. Touch the red (+) probe of the voltmeter to the positive terminal of the power source.

Caution: Voltmeters must be connected with the same polarity as the circuit or damage to the meter may occur.

☐ 5. Touch the black (-) probe to the negative terminal of the power source.

☐ 6. Read the meter and record your reading.

Note: The meter reading shows the difference in voltage levels between the two points. In this case, the voltage should be approximately the same as the setting of the power supply.

☐ 7. While keeping the positive probe on the positive terminal of the power source, move the black probe to touch an exposed conductor on the positive side of the load.

☐ 8. Read the meter and record your reading.

Note: The meter reading shows the potential difference between the power source and that point in the circuit.

☐ 9. While keeping the positive probe on the positive terminal of the power source, move the black probe to touch an exposed conductor on the negative side of the load.

☐ 10. Read the meter and record your reading.

Note: The difference in the reading at Step 8 and Step 10 is the amount of voltage drop across the load.

☐ 11. Place the positive probe on the positive side of the load and the negative probe on the negative side of the load.

☐ 12. Read the meter and record your reading.

☐ 13. Discuss your results with your instructor.

☐ 14. Remove power from the circuit.

☐ 15. Return equipment and materials to their proper storage area.

Job Sheet 6

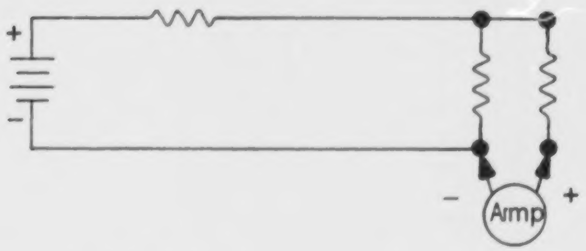
C. Procedure to measure current with an ammeter

☐ 1. Set the power supply to 1.5 volts or install a 1.5-volt battery.

☐ 2. Disconnect a portion of the parallel circuit between two branches.

☐ 3. Touch the black probe of the ammeter to the negative terminal of one branch and the red probe to the negative terminal of a second branch (Figure 1).

Figure 1



☐ 4. Energize the circuit.

☐ 5. Read the meter and record your reading.

☐ 6. Open the circuit switch.

☐ 7. Reconnect the parallel branch portions of the circuit to return it to its original configuration.

☐ 8. Touch the black probe of the ammeter to the negative side of the switch and the red probe to the positive side of the switch.

Note: This should complete a series circuit around the switch.

☐ 9. Read the meter and record your reading.

☐ 10. Repeat Steps 1-9 with the power supply set to 3.0 volts or using two 1.5-volt batteries.

☐ 11. Discuss your results with your instructor.

☐ 12. Remove power from the circuit.

☐ 13. Return equipment and materials to their proper storage area.

Job Sheet 6

D. Procedure to measure resistance with an ohmmeter

☐ 1. Ensure that circuit power is off.

Caution: Never connect an ohmmeter to a circuit that is energized or energize a circuit to which an ohmmeter is connected.

☐ 2. Ensure that the circuit switch is open.

☐ 3. Isolate the component or branch for which resistance is to be measured from the circuit by disconnecting at least one circuit connection.

Note: For example, if you want to measure the resistance of a lamp, disconnect one circuit connection. The more completely the circuit segment to be measured can be isolated, the more accurate will be the reading.

☐ 4. Touch one probe of the ohmmeter to one end of the segment or component to be tested and the other probe to the other end.

☐ 5. Apply power to the ohmmeter.

Note: Ohmmeters provide their own power source. Some apply power as soon as the circuit is completed, some have on-off switches, and others use different designs to provide power application.

☐ 6. Read the meter and record your reading.

☐ 7. Discuss your results with your instructor.

☐ 8. Return the circuit to its original configuration.

☐ 9. Return equipment and materials to their proper storage area.

E. Procedure to measure electrical characteristics with a multimeter

☐ 1. Configure the multimeter to measure voltage.

☐ 2. Set the range setting to a range value suitable for the circuit to be measured.

☐ 3. Perform Procedure B, Steps 1-13 using the multimeter.

☐ 4. Configure the multimeter to measure current.

Job Sheet 6

☐ 5. Set the range setting to a range value suitable for the circuit to be measured.

☐ 6. Perform Procedure C, Steps 1-11 using the multimeter.

☐ 7. Configure the multimeter to measure resistance.

☐ 8. Set the range setting to a range value suitable for the circuit to be measured.

☐ 9. Perform Procedure D, Steps 1-9 using the multimeter.

Evaluator's comments: ______________________________

Shop Orientation and Safety
Unit 2

Job Sheet 7—Measure Electrical Characteristics in a Series-Parallel Circuit

Name ______________________ Attempt Number __________

Date ______________________ Overall Rating __________

Evaluation criteria	**Rating**
• Correct procedures were followed	______
• Equipment was configured correctly	______
• Equipment was used correctly	______
• Correct readings were obtained	______

Introduction: An electronics technician must understand how electrical circuits work and must be able to measure the electrical characteristics of a circuit to determine if it is working correctly. A number of different instruments can be used to take the required readings, and the competent technician knows how and when to use each.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Note: This job sheet describes the use of various types of test equipment to measure electrical characteristics in a parallel circuit. Depending on the equipment used in your facility, you may or may not complete all sections of this job sheet.

A. Equipment and materials

- Voltmeter
- Ammeter
- Ohmmeter
- Multimeter
- Series-parallel circuit with adjustable power supply or various voltages of batteries

B. Procedure to measure voltage with a voltmeter

☐ 1. Set the power supply to 6 volts (or use a 6-volt battery or combination of batteries).

☐ 2. Energize the circuit.

Job Sheet 7

☐ 3. Ensure that the voltmeter is set for DC measurements and a scale that is appropriate to the expected voltage.

☐ 4. Touch the red (+) probe of the voltmeter to the positive terminal of the power source.

Caution: Voltmeters must be connected with the same polarity as the circuit or damage to the meter may occur.

☐ 5. Touch the black (-) probe to the negative terminal of the power source.

☐ 6. Read the meter and record your reading.

Note: The meter reading shows the difference in voltage levels between the two points. In this case, the voltage should be approximately the same as the setting of the power supply.

☐ 7. While keeping the positive probe on the positive terminal of the power source, move the black probe to touch an exposed conductor on the positive side of the load.

☐ 8. Read the meter and record your reading.

Note: The meter reading shows the potential difference between the power source and that point in the circuit.

☐ 9. While keeping the positive probe on the positive terminal of the power source, move the black probe to touch an exposed conductor on the negative side of the load.

☐ 10. Read the meter and record your reading.

Note: The difference in the reading at Step 8 and Step 10 is the amount of voltage drop across the load.

☐ 11. Place the positive probe on the positive side of the load and the negative probe on the negative side of the load.

☐ 12. Read the meter and record your reading.

☐ 13. Discuss your results with your instructor.

☐ 14. Remove power from the circuit.

☐ 15. Return equipment and materials to their proper storage area.

Job Sheet 7

C. Procedure to measure current with an ammeter

☐ 1. Set the power supply to 1.5 volts or install a 1.5-volt battery.

☐ 2. Set up to measure a series portion of the circuit by connecting the ammeter in series with that portion of the circuit.

☐ 3. Energize the circuit.

☐ 4. Read the meter and record your reading.

☐ 5. Open the circuit switch.

☐ 6. To set up to measure a parallel portion of the circuit, remove a segment between parallel branches and connect the ammeter in series with the branches.

Note: See Figure 1 in Job Sheet 7.

☐ 7. Read the meter and record your reading.

☐ 8. Repeat Steps 1-7 with the power supply set to 3.0 volts or using two 1.5-volt batteries.

☐ 9. Discuss your results with your instructor.

☐ 10. Remove power from the circuit.

☐ 11. Return equipment and materials to their proper storage area.

D. Procedure to measure resistance with an ohmmeter

☐ 1. Ensure that circuit power is off.

Caution: Never connect an ohmmeter to a circuit that is energized or energize a circuit to which an ohmmeter is connected.

☐ 2. Ensure that the circuit switch is open.

☐ 3. Isolate the component or branch for which resistance is to be measured from the circuit by disconnecting at least one circuit connection.

Note: For example, if you want to measure the resistance of a lamp, disconnect one circuit connection. The more completely the circuit segment can be isolated, the more accurate will be the reading.

☐ 4. Touch one probe of the ohmmeter to one end of the segment or component to be tested and the other probe to the other end.

☐ 5. Apply power to the ohmmeter.

Note: Ohmmeters provide their own power source. Some apply power as soon as the circuit is completed, some have on-off switches, and others use different designs to provide power application.

☐ 6. Read the meter and record your reading.

☐ 7. Discuss your results with your instructor.

☐ 8. Return the circuit to its original configuration.

☐ 9. Return equipment and materials to their proper storage area.

E. Procedure to measure electrical characteristics with a multimeter

☐ 1. Configure the multimeter to measure voltage.

☐ 2. Set the range setting to a value suitable for the circuit to be measured.

☐ 3. Perform Procedure B, Steps 1-13 using the multimeter.

☐ 4. Configure the multimeter to measure current.

☐ 5. Set the range setting to a value suitable for the circuit to be measured.

☐ 6. Perform Procedure C, Steps 1-9 using the multimeter.

☐ 7. Configure the multimeter to measure resistance.

☐ 8. Set the range setting to a value suitable for the circuit to be measured.

☐ 9. Perform Procedure D, Steps 1-9 using the multimeter.

Evaluator's comments: ______________________________________

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Shop Orientation and Safety
Unit 2

Job Sheet 8—Adjust Oscilloscope Controls for a Stable Waveform Display

Name ______________________ Attempt Number __________

Date ______________________ Overall Rating __________

Evaluation criteria	**Rating**
• Equipment was set up correctly	______
• Correct procedures were followed	______
• Waveform presentation was clear and stable	______

Introduction: The oscilloscope is a valuable tool for the electronics technician. However, to be useful, the scope must be properly set up and adjusted. The exact procedures for setup and adjustment will vary from one model of oscilloscope to another, so this procedure will require that you follow the oscilloscope manufacturer's setup procedures. These are normally contained in the operator's manual provided with the equipment. The operator's manual is also useful in helping you become familiar with the capabilities, controls, and features of the equipment that you will be using. Take a few minutes to review the manual and keep it handy as you use the oscilloscope.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Oscilloscope
- Signal generator
- Test leads

B. Procedure

☐ 1. Set up oscilloscope in accordance with the operator's manual.

☐ 2. Turn on signal generator.

☐ 3. Connect signal generator to oscilloscope.

☐ 4. Adjust the *volts/cm control* so that the peak-to-peak amplitude is visible on the screen.

Job Sheet 8

☐ 5. Set the trigger control to the *internal* position; select the channel receiving the signal generator input.

☐ 6. Adjust trigger level and slope control until waveform is stable.

☐ 7. Set *sweep time/cm* so that waveform is only a few cycles in length.

☐ 8. Readjust all controls to obtain the clearest, most stable waveform trace possible.

☐ 9. Have your instructor check the display.

☐ 10. Once your instructor has approved your waveform, turn off the oscilloscope and signal generator.

☐ 11. Return equipment and materials to their proper storage location.

Evaluator's comments: ______________________________

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Shop Orientation and Safety
Unit 2

Job Sheet 9—Measure Frequency Using an Oscilloscope

Name ______________________________ Attempt Number __________

Date ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
• Equipment was set up correctly	________
• Correct procedures were followed	________
• Waveform presentation was clear and stable	________
• Frequency was correctly computed	________

Introduction: Frequency is the amount of time required for a waveform cycle and it is one of the more common measurements taken with an oscilloscope. It involves determining the time required to complete a cycle. The frequency in Hertz is computed by dividing the time in seconds into 1 (see Assignment Sheet 6). The oscilloscope is used to measure the cycle length and to determine the cycle time based on the sweep rate setting.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Oscilloscope
- Signal generator
- Test leads

B. Procedure

☐ 1. Set up oscilloscope and signal generator for operation.

☐ 2. Connect signal generator to oscilloscope.

☐ 3. Adjust oscilloscope for a stable waveform.

☐ 4. Determine the time of the sine wave and record your reading.

☐ 5. Calculate the frequency of the sine wave and record your answer.

Job Sheet 9

☐ 6. Have your instructor check your answer.

☐ 7. Turn off oscilloscope and signal generator.

☐ 8. Return equipment and materials to their proper storage area.

Evaluator's comments: ____

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Shop Orientation and Safety
Unit 2

Job Sheet 10—Measure AC Voltage Using an Oscilloscope

Name ______________________ Attempt Number __________

Date ______________________ Overall Rating __________

Evaluation criteria	**Rating**
• Equipment was set up correctly	______
• Correct procedures were followed	______
• Waveform presentation was clear and stable	______
• Peak-to-peak voltage was correctly computed	______
• rms voltage was correctly computed	______

Introduction: An oscilloscope can be used to measure AC voltage. The display provides a peak-to-peak representation of AC voltage, which is simply converted to a value based on the number of volts per centimeter (graticule lines). This value can then be converted to effective voltage by multiplying by the constant 0.707, which converts the peak-to-peak value to the root-mean-square value (see Assignment Sheet 5). These calculations are both based on oscilloscope readings.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Oscilloscope
- Signal generator
- Test leads

B. Procedure

☐ 1. Set up oscilloscope and signal generator for operation.

☐ 2. Connect signal generator to oscilloscope.

☐ 3. Adjust oscilloscope for a stable waveform.

☐ 4. Determine the volts/cm setting.

Job Sheet 10

☐ 5. Calculate peak-to-peak voltage and record your answer.

☐ 6. Convert the peak-to-peak value to an rms value and record your answer.

☐ 7. Have your instructor check your answer.

☐ 8. Turn off oscilloscope and signal generator.

☐ 9. Return equipment and materials to their proper storage location.

Evaluator's comments: ____

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Shop Orientation and Safety
Unit 2

Job Sheet 11—Measure DC Voltage Using an Oscilloscope

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

Evaluation criteria	**Rating**
• Equipment was set up correctly	________
• Correct procedures were followed	________
• Waveform presentation was clear and stable	________
• Voltage was correctly computed	________

Introduction: An oscilloscope can be used to measure DC voltage. The display provides a representation of voltage, which is simply converted to a value based on the number of volts per centimeter (graticule lines). This calculation is based on oscilloscope readings.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Oscilloscope
- DC power supply
- Test leads

B. Procedure

☐ 1. Set up oscilloscope and power supply for operation.

☐ 2. Connect power supply to oscilloscope.

☐ 3. Adjust oscilloscope to measure DC voltage.

☐ 4. Determine the volts/cm setting.

☐ 5. Have your instructor check your answer.

☐ 6. Turn off oscilloscope and power supply.

Job Sheet 11

☐ 7. Return equipment and materials to their proper storage location.

Evaluator's comments: ____

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Shop Orientation and Safety
Unit 2

Job Sheet 12—Calibrate an Oscilloscope Probe

Name ________________________ Attempt Number __________

Date ________________________ Overall Rating __________

Evaluation criteria	**Rating**
• Equipment was set up correctly	______
• Correct procedures were followed	______
• Waveform presentation was clear and stable	______
• Probe calibration was successful	______

Introduction: Many pieces of electronic test equipment require periodic calibration. Calibration is the process of ensuring that equipment readings are accurate in terms of an accepted standard. Some equipment must be sent to special laboratories to be calibrated, other equipment is self-calibrating, and some equipment can be calibrated by the operator. Most oscilloscope probes can be calibrated by the operator by using an internal calibration program in the oscilloscope and adjusting for a stable square wave display. This job sheet describes a general procedure for this task; however, you should check the oscilloscope operator's manual for exact steps and guidelines.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Oscilloscope
- Oscilloscope probe
- Oscilloscope operator's manual

B. Procedure

☐ 1. Set up oscilloscope for operation.

☐ 2. Connect probe to oscilloscope input.

☐ 3. Connect probe to calibration jack on oscilloscope.

☐ 4. Adjust oscilloscope for stable square wave display.

☐ 5. Check square wave for distortion in signal.

☐ 6. Adjust oscilloscope probe for no distortion in displayed signal.

☐ 7. Vary adjustment to ensure that there is no distortion when properly adjusted.

Note: If you are not able to eliminate the distortion or if no adjustments lead to distortion, notify your instructor.

☐ 8. Turn off oscilloscope.

☐ 9. Return equipment and materials to their proper storage location.

Evaluator's comments: ______________________________

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Fabrication and Repair
Unit 3

Objective Sheet

Unit Objective

After completing this unit, the student should be able to prepare electronic components and apply fabrication procedures to produce, repair, and test electronic assemblies. The student should demonstrate these competencies by completing the assignment sheets and job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms associated with fabrication and repair to their correct definitions.
2. Match methods of electronic circuitry fabrication to their correct descriptions.
3. Describe component and material preparation steps.
4. Match materials used in electronic circuitry fabrication to their correct descriptions.
5. Identify types of wires and cables used in electronic circuitry fabrication.
6. Identify types of connectors used in electronic circuitry fabrication.
7. Describe methods for installing connectors.
8. List reasons for lead-forming electronic components.
9. List reasons for tinning electronic components.
10. State goals for soldered connections.
11. Complete statements about solder and flux.
12. Select from a list correct guidelines for proper hand soldering.
13. Identify solder joints.
14. Match types of solder defects to their correct descriptions.
15. Describe methods of removing installed components.
16. Label the parts of a printed circuit board.

Objective Sheet

17. List types of printed circuit board construction.

18. Match types of printed circuit board materials to their correct descriptions.

19. Match printed circuit board coatings to their correct descriptions.

20. List methods of removing printed circuit board coatings.

21. Arrange in order the general steps for troubleshooting.

22. Use data books and other resources. (Assignment Sheet 1)

23. Apply troubleshooting principles. (Assignment Sheet 2)

24. Prepare a soldering iron tip for use. (Job Sheet 1)

25. Adjust wire strippers. (Job Sheet 2)

26. Cut and strip low-voltage wire and cable. (Job Sheet 3)

27. Install coaxial cable connectors. (Job Sheet 4)

28. Install ribbon cable connectors. (Job Sheet 5)

29. Install crimp connectors on wires. (Job Sheet 6)

30. Install soldered connectors on wires. (Job Sheet 7)

31. Solder wires to turret terminals and desolder wires. (Job Sheet 8)

32. Splice wires together by means of crimping. (Job Sheet 9)

33. Splice wires together by means of soldering. (Job Sheet 10)

34. Install components using mechanical fasteners. (Job Sheet 11)

35. Install components using swaging. (Job Sheet 12)

36. Tin and form leads on through-hole components. (Job Sheet 13)

37. Install through-hole components on a circuit board. (Job Sheet 14)

38. Install surface-mount components on a circuit board. (Job Sheet 15)

39. Remove through-hole components from a circuit board. (Job Sheet 16)

40. Remove surface-mount components from a circuit board. (Job Sheet 17)

Objective Sheet

41. Repair a printed circuit board. (Job Sheet 18)

42. Inspect an electronic circuit and identify soldering and fabrication defects. (Job Sheet 19)

Fabrication and Repair
Unit 3

Information Sheet

1. **Terms and definitions**

a. **Adhesive**—Substance used to stick objects to each other

b. **Alloy**—Material made by combining two or more metals, such as tin and lead to make solder

c. **Clinch**—Method of helping to secure a component to a circuit board by bending the lead after it has passed through the through-hole

d. **Corrosion**—Chemical reaction between metals and other substances, including air, in which oxides form and the surface of the metal deteriorates

e. **Fabricate**—-To build or manufacture

f. **Female**—Of parts that fit together, referring to the one with a hollow or opening into which the mating part fits

g. **Fillet**—Rounded or concave surface created at the joint between two surfaces, such as a solder joint

h. **Fusion**—Process of joining two objects together by melting part of one or both objects and allowing them to harden together

i. **Intermittent**—Occurring occasionally as opposed to occurring at each opportunity

j. **Lead** —Exposed conductor extending from an electronic component

k. **Lead-forming**—Process of bending and shaping component leads

l. **Male**— Of parts that fit together, referring to the one with an extension that fits into the other part

m. **Oxide**—Product of a chemical reaction in which a substance combines with oxygen

n. **Plating**—Process of covering an object with metal, such as covering a circuit board with solder

o. **Resin**—Synthetic substance used as a liquid that hardens to form a tough plastic

p. **Splice**—To join two similar objects at their ends, especially through the use of a third object that overlaps the first two

q. **Surface-mount**—Type of circuit board and electronic component design in which the components are soldered or bonded to the surface of the circuit board

r. **Terminal**—Point in an electrical circuit designed to connect with another part of the circuit

s. **Through-hole**— Type of circuit board and electronic component design in which the component leads pass through the circuit board and are soldered on the side opposite installation

t. **Troubleshooting**—Systematic process for determining the cause of a malfunction in a machine or piece of equipment

u. **Workmanship**—Quality of labor used to produce an object as reflected in the product's conformity to standards

2. Methods of electronic circuitry fabrication

a. Soldering—Use of a metal alloy that is melted to form a coating over joined parts and allowed to harden

b. Bonding—Use of an adhesive to join parts

c. Crimping—Use of pressure to deform parts to hold them together

d. Threaded fasteners—Use of mechanical devices designed in sets with matching interlocking grooves

e. Rivets—Use of metal devices that are inserted through holes and then folded over to prevent them from being pulled back through the holes

f. Swaging—Use of specially designed components that are pressed into their locations under extreme pressure

g. Mating—Use of sets of parts that fit together with sufficient pressure or with built-in locking devices so that they are held in place

Examples: Mating connectors, sockets, snap-in parts

h. Encapsulation—Use of a special substance that is poured as a liquid into a mold that contains parts and which then hardens to encase the parts

i. Wrapping—Use of tape or other flexible covering that is wound around parts or the winding of one part around another part

Examples: Thermal tapes, wire wrap

3. Component and material preparation steps

a. Stripping—Removing the insulation from wire or cable

b. Tinning—Coating the end of a lead or wire with solder

c. Lead-forming—Bending the lead of a component to create a certain shape

d. Loading—Installing parts in a circuit board prior to soldering them

e. Cleaning—Removing corrosion and contaminants from surfaces

Information Sheet

f. Drying (baking)—Heating a component or assembly to remove moisture from its surface

g. Burn-in—Applying power to a part or assembly for a period of time to ensure proper operation or to eliminate parts that have a short operational life

h. Screening—Testing parts to verify that they function or to select parts with best performance levels

i. Scuffing—Adding a rough texture to a surface to improve bonding

4. **Materials used in electronic circuitry fabrication**

a. Flux—Chemical used to clean surfaces to be soldered before and during soldering and to aid the fusion process

b. Solder—Soft metal alloy, usually of tin and lead, used for plating and fusing metals together

c. Solder paste—Bonding agent used with surface-mount components

d. Epoxy resin—Synthetic material used for bonding, coating, and in the construction and repair of circuit boards and other parts

e. Phenolic—Resin-based material usually containing cloth or paper for improved strength and used as an insulating base for circuit boards, bus bars, and other structures

f. Adhesive—Any of various compounds used to bond parts together

g. Potting compound—Substance used to encase parts for encapsulation

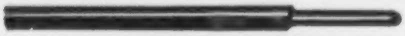
h. Conformal coating—Various substances that are applied to circuit boards and other assemblies as a final sealant

i. Ink—Colored compounds that can be stamped, penned, brushed, or otherwise applied to parts and assemblies to identify components and their locations and to provide other information, such as manufacturer, serial number, etc.

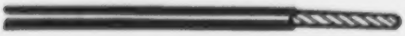
j. Shrink tubing—Hollow, rubbery substance that fits over parts and that decreases in diameter when heat is applied to it

5. **Types of wires and cables used in electronic circuitry fabrication**

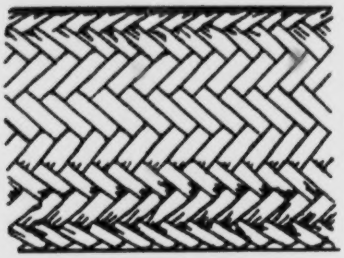
a. Solid single conductor



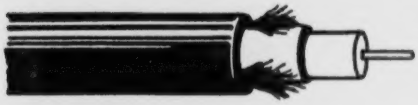
b. Stranded single conductor



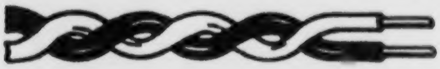
c. Shielded



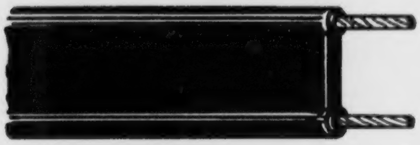
d. Coaxial



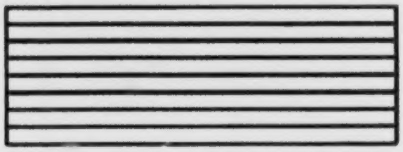
e. Twisted



f. Twin lead



g. Flat (ribbon) cable

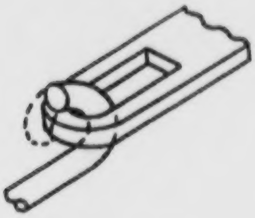


6. Types of connectors used in electronic circuitry fabrication

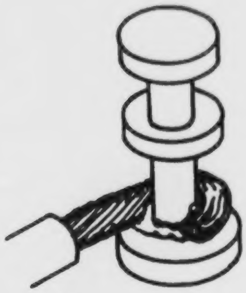
Note: There are numerous ways of providing removable connections in electrical circuits. Such connections are designed to allow operators and service technicians to easily reconfigure circuits, such as connecting speakers to a stereo, plugging a telephone into a circuit, installing batteries in a CD player, connecting a monitor to a computer, etc. Often these connectors come in mating pairs, such as pins and sockets or plugs and jacks. The following list is intended to acquaint you with some of the more common connectors, terminals, headers, and similar components with which you are likely to work. For most of the types shown below, there are often many variations in design.

Information Sheet

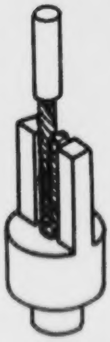
a. Terminal lug



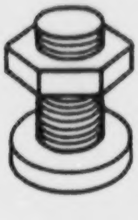
b. Turret terminal



c. Bifurcated terminal

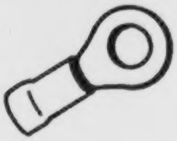


d. Threaded terminal post

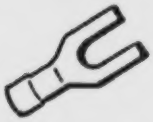


Information Sheet

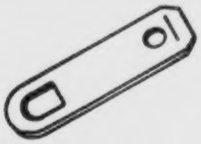
e. Ring terminal



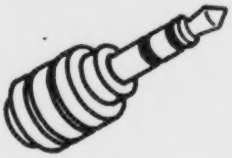
f. Fork terminal



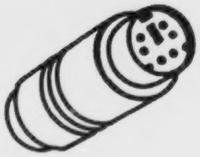
g. Blade terminal



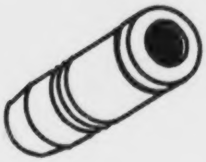
h. Pin terminal



i. Socket

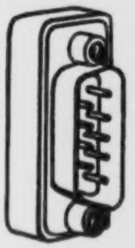


j. Jack

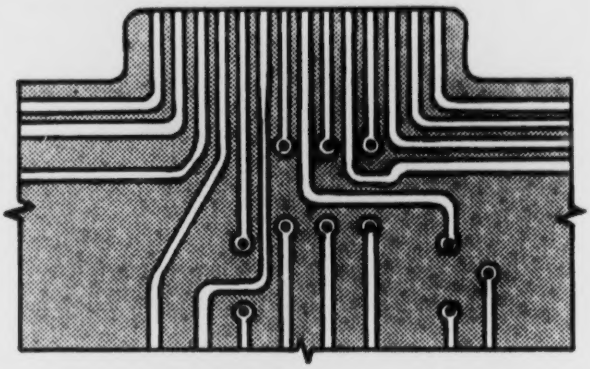


Information Sheet

k. Multi-pin connector



l. Edge connector



7. **Methods for installing connectors**

a. Soldering—Connectors can be soldered onto wires or wires can be soldered to terminals

b. Crimping—Connectors can be crimped onto wires

c. Bonded—Connectors can be embedded in an assembly as part of the manufacturing process, such as edge connectors on a circuit board

d. Encapsulated—Connectors can be inserted into a connector body which is then filled with potting compound

e. Threaded fasteners—Connectors can be installed on an assembly with threaded fasteners or secured to a threaded terminal post with a nut

f. Rivets—Connectors and sockets are sometimes installed on assemblies through the use of rivets

g. Self-locking—Pins and other connectors may be self-locking and frequently require special insertion and removal tools

Information Sheet

8. Reasons for lead-forming electronic components

a. To align the leads with the installation area, such as the holes for a through-hole component or the adhesive pad area for a surface-mount component

b. To improve the installation or the soldering surface, such as in clinching leads

c. To provide stress relief

Note: Electronic components installed on circuit boards are subject to vibration and other stresses. These stresses can eventually break the thin metal of the leads. By creating a bend in the lead, the effects of vibration and other stresses are redirected and reduced.

9. Reasons for tinning electronic components

a. To protect the leads or wires from corrosion

b. To improve the solderability of the lead or wire

c. To prevent stranded wires from unraveling

10. Goals for soldered connections

a. To provide an electrical connection with virtually no resistance

b. To prevent corrosion of conductors that would be exposed if not coated with solder

c. To provide a strong mechanical connection

d. To provide a seal to keep moisture and other contaminants out of the circuitry

11. Solder and flux

a. Solder

- Generally classed by its percentage of tin versus lead, such as 60/40 (60% tin and 40% lead)
- Available in bars, sheets, wire spools, and special shapes, such as pellets or washers
- Wire spool solders are classed by their diameter and are commonly used for hand soldering
- Wire spool solders may contain *cores*, special chemicals in a hollow space within the solder, with the most common cores being acid or rosin fluxes

b. Flux

- A chemical agent that removes the corrosion (oxide) films that form on metal surfaces that are exposed to air and humidity
- Applied by hand before or during soldering

Information Sheet

- Flux is contained in the core of some wire spool solders
- Organic salt (chloride) fluxes are the strongest oxide removers
- Organic acid or base fluxes are medium strength oxide removers and allow fast soldering
- Rosin fluxes are medium strength oxide removers but do not become effective until heated, thus allowing good control
- Water-based fluxes are low to medium strength oxide removers and tend to be more environmentally safe

12. Guidelines for proper hand soldering

a. Follow guidelines for the specific soldering task.

Note: Most companies have *workmanship standards* that define what is acceptable for most processes done in their facilities, including soldering. Many government and military agencies publish soldering standards. Additionally, the drawings that define how to build the assembly may specify soldering processes or standards.

b. Maintain the soldering facility as a clean, dust-free environment with a relative humidity of 30-65% and a temperature of 65-85°F (20-30°C).

c. Use the proper size and shape of tip for the job to be done.

d. Use a solder that is suitable for the job.

e. Use the proper temperature for the solder and type of installation.

Note: It may be necessary to use an additional source of heat such as a hot plate if soldering on a circuit board with a built-in heat sink or it may be necessary to use a heat sink on the component lead to prevent the heat from damaging heat-sensitive components.

f. Tin the tip of the soldering iron to help with heat transfer.

g. Clean the area to be soldered with flux.

h. Hold the tip of the soldering iron at the point to be soldered.

i. Hold solder against the point to be soldered on the opposite of the lead or component from the soldering iron tip.

j. Allow the solder to melt and flow smoothly into the solder joint area.

k. Keep to a minimum the time that the soldering iron is in contact with the component, generally no more than 3 seconds per application.

l. Examine the solder joint and remove the solder if the joint is unacceptable.

m. Periodically remove excess solder from the soldering iron tip with a damp sponge.

n. Install components as required by the drawing and other standards, including correct polarity, correct location, and correct lead forming.

o. Use as little solder as possible while still making a satisfactory connection and remove excess solder.

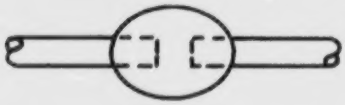
p. Clean the soldered area(s) when soldering is complete.

q. Turn off the soldering equipment if it is not to be used to preserve the tip and electrical circuitry.

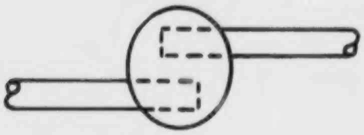
r. Wash your hands immediately after soldering and particularly before eating, drinking, or smoking.

13. Solder joints

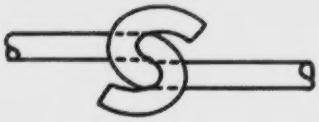
a. Butt connections



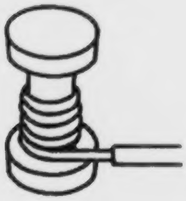
b. Lap connections



c. Wire hook

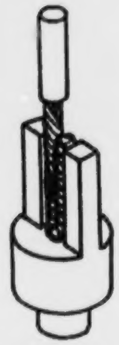


d. Wire wrap

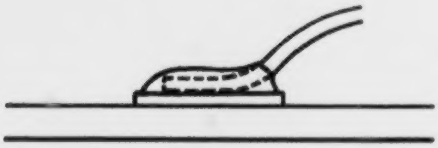


Information Sheet

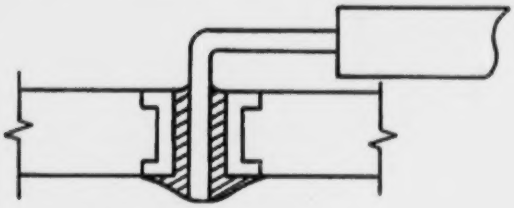
e. Bifurcated terminal



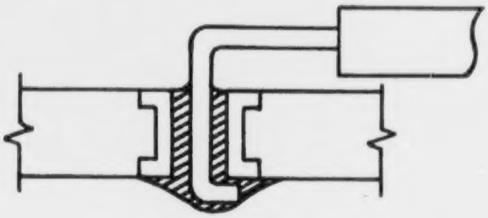
f. Flat-mount fillet



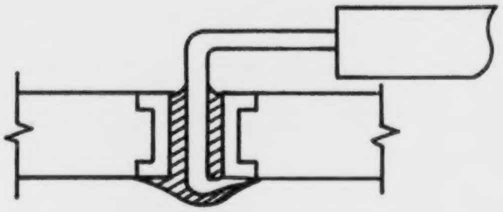
g. Straight through-hole



h. Clinched through-hole



i. Swaged or spaded lead



14. Types of solder defects

a. Void—Hollow area in joint without solder

b. Pin hole—Small hole in the surface of the solder

c. Bridge—Excess solder that forms a short between two conductors

d. Peak—Excess solder that rises above the intended solder joint

Note: One danger of peaks is that they can get bent over to form a bridge.

e. Inadequate solder or flow—Amount of solder in joint does not provide a good electrical or a good mechanical bond or does not fill required connection area

f. Poor wetting—Solder does not flow evenly on a surface or does not hold together

g. Bird cage—Condition of stranded wire conductor in which the wires have separated in or above the solder joint

h. Wicking—Condition in which solder or flux travels up a wire and under the insulation

i. Lifted pad—Separation of a solder pad on a circuit board, usually as a result of excessive heat during soldering or desoldering or excessive physical pressure during component removal

j. Measling—Breakdown of the surface of a circuit board, often creating pockmarks on the board and usually resulting from excessive heat during soldering (especially wave soldering) or exposure to strong chemicals such as harsh organic salt fluxes

k. Thermal damage—Visible or invisible damage to a component or assembly as a result of excessive heat during soldering

Examples: Circuit board warpage, reduction in the performance or life of a component

Information Sheet

15. Methods for removing installed components

a. Solder wick—Use of a braided wire that allows melted solder to flow up into the braid

b. Desoldering bulb—Use of a suction device that is activated by squeezing a bulb to create low pressure that draws melted solder into the bulb

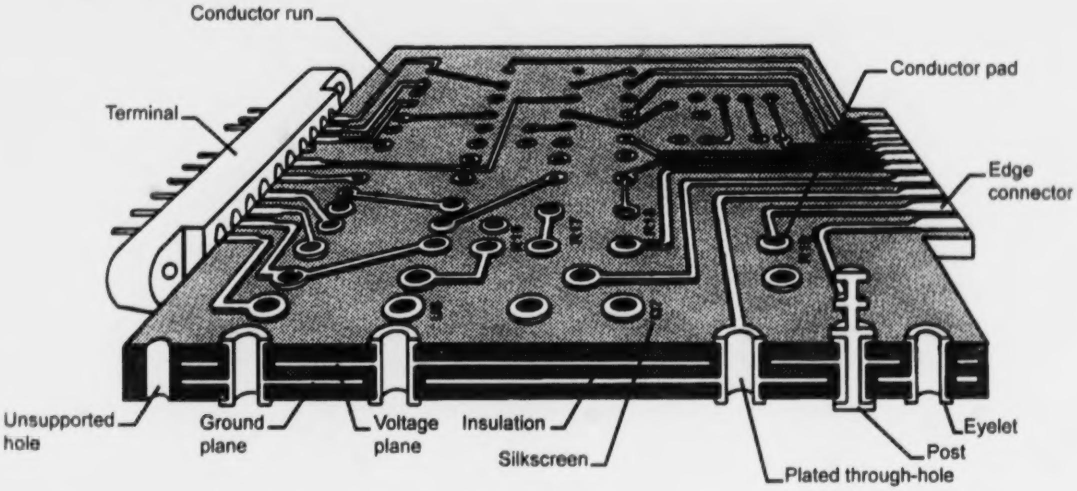
c. Solder sucker—Use of a suction device that is activated by moving a plunger to create low pressure that draws melted solder into the body of the device

d. Heat and pull—Process of applying heat with a soldering iron, hot plate, directed heat, or other source to melt the solder to allow the component to be pulled from the board

e. Clip and pull—Method in which the leads of the component are cut and then the solder joints are desoldered to allow removal of the leads

f. Solder bath—Method of applying new solder in an effort to get the new solder to mix with the old solder so that both can be removed

16. Parts of a printed circuit board


Conductor run
Conductor pad
Terminal
Edge connector
Unsupported hole
Ground plane
Voltage plane
Insulation
Silkscreen
Eyelet
Post
Plated through-hole

17. Types of printed circuit board construction

a. Single-sided

b. Double-sided

c. Multiple layer laminations

d. Flex circuit

e. Backplane

Information Sheet

18. Types of printed circuit board materials

a. Epoxy glass—Rigid material made of glass fibers embedded in epoxy resin and generally assembled as laminated layers

b. Phenolic resin—Rigid material made of cotton or paper impregnated with resin and suitable for moderate temperature applications

c. Ceramic—Slightly flexible material made of clays

d. Mylar—Flexible material made of synthetic plastics

e. Polyimide—Rigid material made of resins and often assembled as laminated layers

f. Metal plate—Flexible plates made of conductive metals such as copper and generally used with other materials as a laminated layer

19. Printed circuit board coatings

a. Acrylic varnish—Compound of hydrogen cyanide and acetylene; early coating with limited use today in mild environment applications

b. Epoxy resin—Compound of carbon and oxygen in specially bonded molecules; provides good seal with moderate use today

c. Polyurethane—Compound of synthetic rubbers; widely used today due to good sealing properties and ability to vary application thickness

d. Silicone—Compound of synthetic rubbers; used in specific applications such as coating modules on the circuit board rather than coating the entire circuit board

e. Paralene—Synthetic plastic that produces thin, hard coating; popular for many electronic applications

20. Methods of removing printed circuit board coatings

a. Solvents

b. Abrasives

c. Hot air

d. Thermal knives

e. Debonding agents

Note: Solvents work to dissolve the coating, whereas debonding agents work to loosen the coating from the circuit board surface. As with any chemical, be sure that the agent is approved for use. For example, at one time freon was a popular debonding agent for silicone coatings. However, the EPA has restricted the use of freon due to its effects on the earth's ozone layer.

Information Sheet

21. General steps for troubleshooting

Note: If the manufacturer of the malfunctioning equipment provides troubleshooting instructions, you should follow them. However, if troubleshooting instructions are not available, the steps below will provide guidance for a general troubleshooting process. Because these are general steps, however, they may require modification for a specific malfunction or a specific piece of equipment.

a. Inspect the equipment for any visible indications of a problem, such as a loose power cord, scorched areas, melted components, loose connectors, broken solder joints, etc.

b. List the symptoms of malfunctioning and confirm the extent to which the malfunctions exist.

Note: If an electronic device is not operating correctly, there will be symptoms: things that the equipment does that it should not do, or things that it does not do that it should. The technician should note all of these symptoms and should also determine under what conditions they occur. For example, if a computer will not read a diskette, will the same problem occur if the technician tries a different diskette? If a television does not have a picture on one channel, does it have a picture on other channels? If the radio on a boom box does not work, does the CD player?

c. Refer to the equipment block diagram or, if no block diagram is available, create a block diagram based on your best understanding of how the equipment operates.

d. Analyze the symptoms (including any visible signs that were found) in terms of the block diagram to determine which section of the equipment is the most likely source of the symptoms.

e. Begin testing that section of the equipment, starting at the output and working back toward the input.

f. Test suspected bad components or replace suspected bad components with known-good components to verify operation.

Note: It is sometimes simpler to swap out components with parts that are known to be good than to do the required testing. However, this can also lead to damaging the good component. For example, if a fuse is blown and the technician simply replaces the fuse, the replacement fuse is likely to blow if the source of the problem is a short in the circuit.

g. If the malfunction is intermittent or does not appear during testing, it may be necessary to change the test conditions, such as applying heat or coolant to re-create the conditions under which the problem was observed.

h. Once the problem has been isolated, evaluate the costs of repairing the equipment versus replacing it and the costs and convenience of various repair options to determine a course of action.

Note: The technician who services equipment for the public must be able to work with customers to determine the best course of action from the customer's viewpoint. For example, if a VCR will cost $150 to repair while a new one costs $200, the customer may choose to buy a new one. If replacing a defective component on a circuit card costs $35 while buying a new circuit card costs $45, the customer may decide to save the $10 and have the circuit card repaired. However, the same customer may decide to replace the circuit card if it is currently available, but the replacement part must be ordered and will not be received for three weeks. The skilled technician is able to evaluate this type of information and make decisions on behalf of his or her company or to advise customers on their options.

Fabrication and Repair
Unit 3

Assignment Sheet 1—Use Data Books and Other Resources

Name ______________________ Overall Rating ______________

Evaluation Criteria	**Rating**
• Directions have been followed	________
• Minimum of 85 percent of answers are correct	________

Note: The value of each answer will depend on which questions are applicable.

Introduction: An electronics technician cannot be expected to remember every detail about the parts and components that are used in the industry, especially in light of how quickly changes take place in electronics products. Therefore, skilled technicians learn to use the resources that are available to find out information about the parts, materials, and equipment with which they work. These resources may be available in the form of books, articles, magazines, papers, microfiche, microfilms, compact discs, on the Internet, and in other formats. Some of the more common resources include:

- **Handbooks.** Collections of pertinent general information, such as formulas for calculating values, tables of values, listings of abbreviations and symbols, bandwidths, etc.
- **Data books.** Collections of information about specific topics, such as systems, electronic components or families of components, devices, etc., generally providing detailed information about performance, electrical characteristics, environmental limitations, and other information. Data books may cover a range of available products or they may be limited to the products of one manufacturer.
- **Data sheets.** Generally extracts from data books, a data sheet usually provides information about one product or a small number of similar products.
- **Catalogs.** Provide limited technical information but give an overview of products and information related to ordering them.
- **Service manuals.** Usually developed for a specific piece of equipment, service manuals explain how to maintain and repair a device and often contain troubleshooting guides.
- **Operator's or user's manuals.** Provide information on how to set up and operate a piece of equipment with limited information on maintaining or repairing the device.

This assignment sheet will allow you to practice using some of the resource materials available in your facility.

Assignment Sheet 1

Directions: This assignment sheet consists of two parts. For the first part, refer to the sample page from a data book provided on the opposite page. Use that information to answer the questions below.

The second part of the assignment sheet involves using resources in your facility. Your instructor will assign you a part or a piece of equipment and refer you to available resources. Using the resources, complete the form provided at the end of this assignment sheet.

Part 1

1. What is the name of this part and its part number and manufacturer?

   ____

2. What is the function of the part?

   ____

   ____

3. What are the electrical characteristics of this part?

   a. Maximum collector-emitter voltage: ______________________

   b. Maximum emitter-base voltage: ______________________

   c. Maximum collector current: ______________________

   d. Base-emitter ON voltage: ______________________

4. What are the environmental limitations of this part?

   a. Operating temperature: ______________________

   b. Storage temperature: ______________________

   c. Maximum soldering temperature and touch time:

      ____

   d. Junction to case thermal resistance: ______________________

5. At what temperature were the values determined?

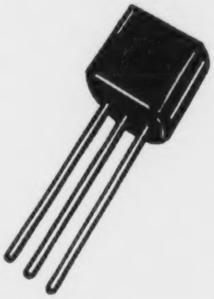
   ____

Assignment Sheet 1

Proton Power Products

Data Sheet

2N4402 General Purpose PNP Transistor



Description: A general purpose silicon transistor for use in home and light industrial systems.

Environmental Characteristics	
Operating temperature:	0°C to 70°C
Storage temperature:	-55°C to 150°C
Maximum junction temperature:	150°C
Lead temperature (10 seconds soldering):	300°C
Thermal resistance (junction to ambient):	200°C/watt
Thermal resistance (junction to case):	80°C/watt

Electrical Characteristics	
Maximum collector-emitter voltage:	-40 volts DC
Maximum collector-base voltage:	-40 volts DC
Maximum emitter-base voltage:	-5 volts DC
Maximum collector current:	-100 milliamps DC
Maximum emitter current:	-100 milliamps DC
DC current gain:	100-300
Collector-emitter saturation voltage:	-0.25 volts DC
Base-emitter ON voltage:	-0.6 to -1.0 volts DC

Note: Values for ambient temperature of 25°C.

Assignment Sheet 1

Part 2

Note: Answer Questions 1-7 for the assigned component.

1. What is the component and its part number? ______________________________

2. Who is the manufacturer? ____

3. What is the main function of the component? Briefly explain its function and purpose.

   ____

   ____

4. What are the electrical characteristics of the component?

   ____

   ____

   ____

5. What are the environmental limitations of the component?

   ____

   ____

   ____

6. If provided, what are the manufacturers and part numbers of parts of components for which this one can serve as a replacement?

   ____

   ____

7. In the space below, draw the part and identify significant features, such as the ground pin, polarity, etc.

Assignment Sheet 1

Note: Answer Questions 8-16 for the assigned device.

8. What is the device, including model number? ______________________________

9. Who is the manufacturer? ______________________________

10. What are the inputs and outputs of the device as described in the resource?

____

____

____

11. What are the electrical characteristics of the device?

____

____

____

12. What are the environmental limitations of the device?

____

____

____

13. If the device uses a power supply, where is it located and what is its part number?

____

____

14. If the resource provides troubleshooting information, in what form is this information presented (table, flow diagram, etc.) and on what page is it located?

____

____

15. If provided, what is the technical assistance telephone number? ________________

16. On the back of this page, sketch the front panel of the device and label major controls, indicators, displays, and other features.

Fabrication and Repair
Unit 3

Assignment Sheet 2—Apply Troubleshooting Principles

Name ______________________ Overall Rating ______________

Evaluation Criteria	Rating
• Directions have been followed	________
• Minimum of 80 percent of answers are correct	________
Note: Each correct answer is worth 10 points.	

Introduction: In the Information Sheet, you studied about a process called *troubleshooting.* You learned that troubleshooting is a systematic approach to trying to determine what is wrong with a device that is malfunctioning. In some cases, resources are available to help the technician in troubleshooting a specific device. In other cases, technicians have to rely on their understanding of how the equipment works and the basic principles of troubleshooting in order to determine the cause of a malfunction. This assignment sheet provides you with an opportunity to practice both approaches to troubleshooting.

Directions: This assignment sheet is divided into two parts. The first part provides you with a troubleshooting chart for a video cassette recorder. You will then be required to answer questions based on the troubleshooting chart.

In the second part, you will be presented with descriptions of equipment malfunctions. You will then be required to answer questions about troubleshooting those malfunctions based on what you know about the principles of troubleshooting.

In each part, the questions will offer four possible answers. Write an "X" in the space beside the answer that is most correct.

Assignment Sheet 2

Note: Questions 1-10 refer to the troubleshooting chart on the opposite page.

1. What is the initial trouble indication addressed by this chart?

   ______a. Machine has no output

   ______b. No picture or faulty picture on screen

   ______c. Switches in wrong position

   ______d. None of the above

2. Step 3 recommends trying a different videotape. If this corrects the problem, which of the following was the most likely cause of the problem?

   ______a. TV monitor was bad

   ______b. Original tape was incorrect size

   ______c. Original tape was bad

   ______d. Electromagnetic interference from other electronic equipment

3. If the VCR is found to have defective plugs or cables, what does the table suggest to do?

   ______a. Change them for good ones

   ______b. Conduct continuity testing

   ______c. Replace the VCR

   ______d. Try a test tape

4. What is the purpose of using another TV monitor?

   ______a. To determine if the original tape was bad

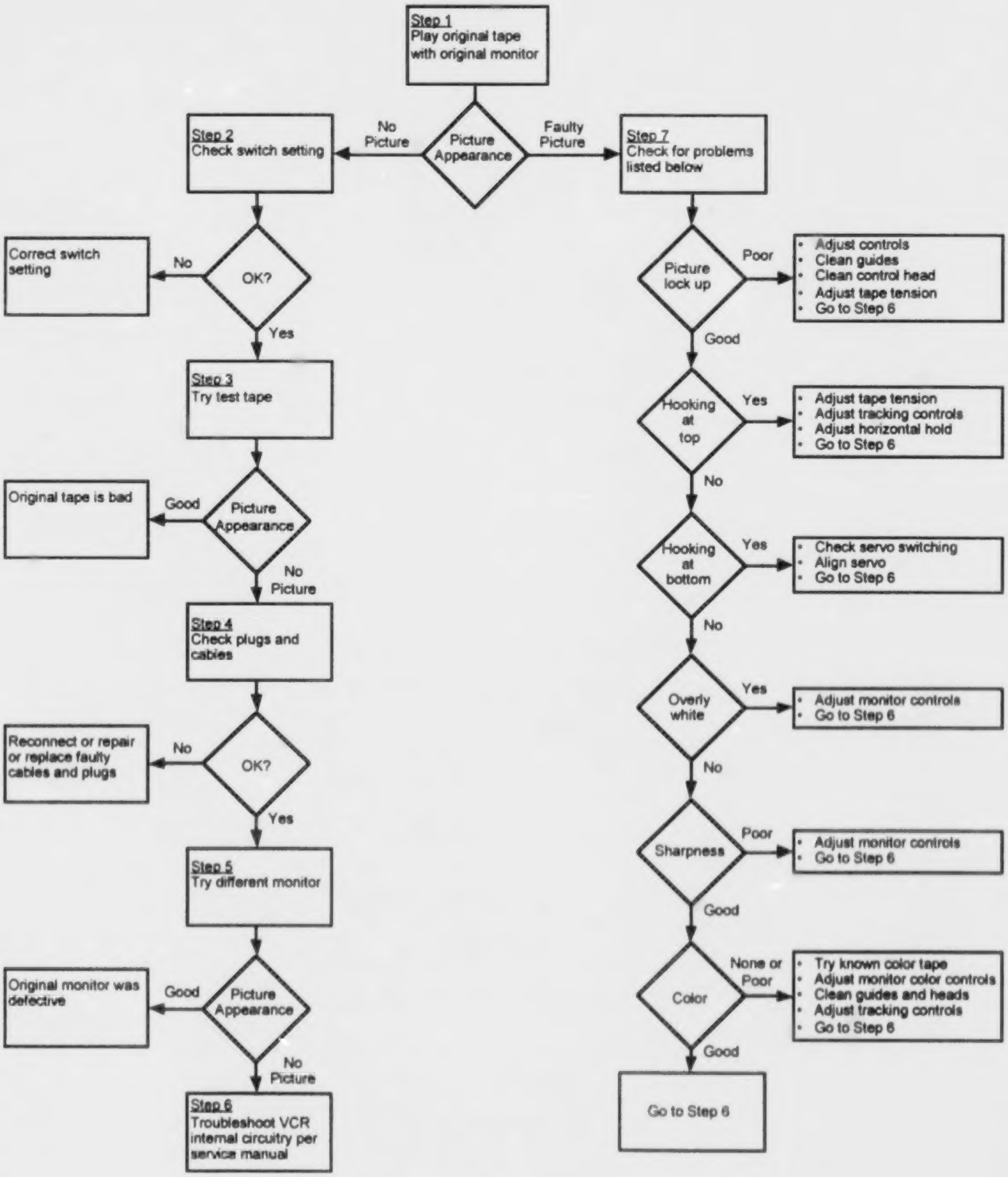
   ______b. To determine whether the switch settings are wrong

   ______c. To determine if the cables and plugs are good

   ______d. To determine whether the VCR has output

Assignment Sheet 2

Chart 1: VCR produces no picture or faulty picture in PLAY


Step 1
Play original tape with original monitor
Picture Appearance
No Picture
Faulty Picture
Step 2
Check switch setting
OK?
No
Correct switch setting
Yes
Step 3
Try test tape
Picture Appearance
Good
Original tape is bad
No Picture
Step 4
Check plugs and cables
OK?
No
Reconnect or repair or replace faulty cables and plugs
Yes
Step 5
Try different monitor
Picture Appearance
Good
Original monitor was defective
No Picture
Step 6
Troubleshoot VCR internal circuitry per service manual
Step 7
Check for problems listed below
Picture lock up
Poor
• Adjust controls
• Clean guides
• Clean control head
• Adjust tape tension
• Go to Step 6
Good
Hooking at top
Yes
• Adjust tape tension
• Adjust tracking controls
• Adjust horizontal hold
• Go to Step 6
No
Hooking at bottom
Yes
• Check servo switching
• Align servo
• Go to Step 6
No
Overly white
Yes
• Adjust monitor controls
• Go to Step 6
No
Sharpness
Poor
• Adjust monitor controls
• Go to Step 6
Good
Color
None or Poor
• Try known color tape
• Adjust monitor color controls
• Clean guides and heads
• Adjust tracking controls
• Go to Step 6
Good
Go to Step 6

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Assignment Sheet 2

5. If the first playing of the tape with the original monitor gives a faulty picture, which step of the procedure should come next?

______a. 2

______b. 5

______c. 7

______d. None of the above; this chart does not address a situation where the monitor displays a faulty picture

6. At Step 7, which of the following is NOT considered to be a possible problem indication?

______a. Picture does not lock up

______b. Picture is overly white

______c. No picture

______d. Picture is not sharp

7. If the picture quality is poor at Step 7 so that the picture exhibits hooking at the top, which of the following is the correct sequence of procedures if the problem continues?

______a. Adjust tape tension; adjust tracking control; adjust horizontal hold; troubleshoot VCR internal circuitry per service manual

______b. Adjust tracking control; adjust tape tension; adjust horizontal hold; troubleshoot VCR internal circuitry per service manual

______c. Check servo switching; align servo; troubleshoot VCR internal circuitry per service manual

______d. Align servo; check servo switching; troubleshoot VCR internal circuitry per service manual

8. If the picture is overly white, which of the following is NOT a likely cause of the problem?

______a. The monitor adjustment

______b. A malfunction in the monitor

______c. The VCR

______d. A problem with the tape or the quality of recording

Assignment Sheet 2

9. If the picture has no color or if the color is bad, which of the following is a possible cause?

______a. The tape is not color

______b. The monitor does not display color

______c. The VCR heads are dirty

______d. All of the above

10. At Step 6, if there is still no picture, the technician should do which of the following?

______a. Exit the troubleshooting procedure

______b. Troubleshoot VCR internal circuitry per service manual

______c. Go to Step 7 and complete the listed procedures

______d. Reconnect VCR to original monitor and see if problem has been corrected

Note: Questions 11-20 contain descriptions of equipment malfunctions. Answer the question in terms of the description with that question and your knowledge of troubleshooting principles.

11. You are using an oscilloscope when it just stops working and the screen goes blank. What would be your first troubleshooting step?

______a. Hang a defective equipment tag on the oscilloscope

______b. Create a block diagram describing the operation of the oscilloscope

______c. Inspect the oscilloscope for any visible indications of a problem

______d. Go check out a replacement oscilloscope

12. You are troubleshooting an audiocassette player that will not produce any sound. The cassette turns but no sound is heard, even after you have tested it with a known good tape. Which of the following is a good next step in the troubleshooting process?

______a. Check to see if there is output at the headphone jack

______b Check for continuity through the power cord

______c. Replace the amplifier

______d. Check for electrical output at the cassette player heads

Assignment Sheet 2

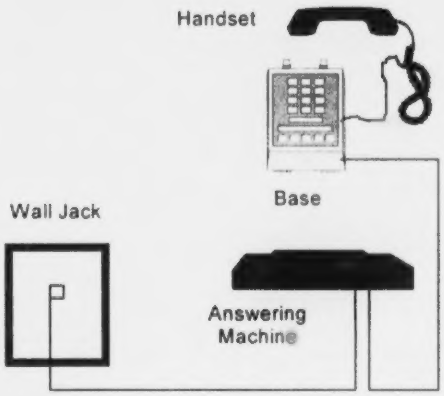
13. A telephone answering machine system consists of the following major functional blocks: the wall jack, the answering machine, the telephone base, and the telephone handset, as shown in the illustration below. If the answering machine does not record messages, which of the following lists shows the most likely cause of the problem?

______a. The wall jack

______b. The wall jack or the answering machine

______c. The wall jack, the answering machine, or the telephone base

______d. Any of the four major components



14. A CD player has intermittent sound, especially after it has played a couple of discs. Which of the following is NOT a likely source of the problem?

______a. A loose drive belt

______b. A defect in the circuit board

______c. An inoperative laser

______d. A loose connection in the speaker

15. A VCR stops working as it plays a tape, resulting in "noise" on the television. You notice a puff of smoke behind the television and, upon checking, find a scorched place on the electrical outlet above the VCR power cord. Based on this information, which of the following would you rule out as a cause of the problem?

______a. The VCR power cord

______b. A lack of power to the electrical outlet

______c. The VCR drive motor overheating

______d. All of the above can be ruled out

Assignment Sheet 2

16. The block diagram for a computer system consists of the main computer, the monitor, the keyboard, and the printer. To print a document, the operator presses the F7 key on the keyboard and hits ENTER. No document is printed. Which component is not a likely cause of the problem?

______a. The main computer

______b. The keyboard

______c. The monitor

______d. The printer

17. A television does not produce any sound while a videotape is being played through it. Which of the following are easily verified problems that should be checked before looking for defects in the television system?

______a. The sound volume is turned down

______b. The television sound is muted

______c. The tape does not have sound recorded on it

______d. All of the above are easily verified

18. In trying to isolate a problem with a computer system that at one time printed documents but now will not print documents, a technician decides to hook a different but identical printer and printer cable into the system to see if the problem is fixed by swapping system components. Is there a problem with this approach?

______a. There is a problem because the printer is the most likely cause of the problem and it should have been connected to a different computer.

______b. There is a problem because the technician has not verified that the computer is operational.

______c. There is a problem because two parts (the printer and the cable) have been substituted at the same time.

______d. There is no problem with this approach.

Assignment Sheet 2

19. A technician has isolated a problem in an electronic security system to the motion detectors. Which of the following is the correct troubleshooting method for continuing the process?

______a. The technician should test each motion detector electrically.

______b. The technician should test the continuity of the cable that connects the motion detectors to the signal relay.

______c. The technician should test the signal relay.

______d. The technician should check to see whether there is a signal from the relay to the processor circuit card.

20. A combination CD player-audiocassette player-radio does not produce any sound when the radio is switched on. Which of the following is a way of verifying the extent of the malfunction?

______a. Try another radio station

______b. Try switching from FM to AM radio

______c. Listen to the radio with headphones

______d. All of the above

Fabrication and Repair
Unit 3

Job Sheet 1—Prepare a Soldering Iron Tip for Use

Name	______________________	Attempt Number	______________
Date	______________________	Overall Rating	______________

Evaluation Criteria	Rating
• Procedure was done correctly	________
• Safety precautions were observed	________
• Tip was satisfactorily cleaned and shaped (if required) or replaced	________
• Tinning was even and adequate without being excessive	________

Introduction: To function properly, a soldering iron must transfer heat efficiently and not introduce contaminants into the solder joint. For these reasons, the tip of the soldering iron must be clean and clear of build up from solder and corrosion. All soldering iron tips can be cleaned and some can be filed to remove excessive buildup and return the tip to its original shape. The exact preparation depends on the type of tip.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Soldering iron and stand
- Damp sponge
- Fine wire brush
- Fine metal file
- Solder
- Cleaning flux
- Tinning oil

B. Procedure

☐ 1. While the soldering iron is cool, examine the tip.

☐ 2. If the tip is corroded or has solder buildup, try cleaning it with cleaning flux.

☐ 3. If the cleaning flux does not clean the tip adequately, use the wire brush to clean it.

Job Sheet 1

☐ 4. If the tip does not come clean with a wire brush, try an alternate cleaning method, depending on the type of tip:

- File copper tips to shape them into a wedge.
- File iron-clad tips if directed to do so by your instructor or replace them.
- Heat gold-plated tips and clean with a damp sponge.

☐ 5. If the tip will not come clean with any of the above steps, replace the tip.

☐ 6. Apply power to the soldering iron and allow it to heat to a normal operating temperature in the stand.

☐ 7. Once the soldering iron has reached operating temperature, use a clean applicator to apply a drop of tinning oil to each surface of the soldering wedge.

☐ 8. Apply a thin coat of solder to the surfaces of the tip soldering wedge, using the damp sponge to help cool the solder.

Caution: Take care not to let hot solder drip onto your skin or clothes.

☐ 9. Once the tip is satisfactorily tinned, remove power from the soldering iron and allow it to cool.

☐ 10. Return equipment and materials to their proper storage location.

Evaluator's comments: ______________________________

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Fabrication and Repair
Unit 3

Job Sheet 2—Adjust Wire Strippers

Name ______________________ Attempt Number ______________

Date ______________________ Overall Rating ______________

Evaluation Criteria	**Rating**
• Procedure was followed correctly	________
• Stripper was properly adjusted	________
• Stripped wires did not exhibit nicks or cut strands	________

Introduction: One of the important tools that an electronics technician uses is the wire stripper. There are several designs of wire strippers, some of which offer cutting slots for various sizes of wires while other designs adjust for stripping different diameters of wire. For the latter type, proper adjustment is critical to ensure that the insulation is efficiently removed without damaging the conductor.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Adjustable wire strippers
- Several lengths of various diameter solid and stranded insulated conductors
- Any tools required for adjustment mechanism on strippers

B. Procedure

☐ 1. Examine strippers to determine type of adjustment mechanism.

Note: The two most common adjustment methods use either an adjustable jaw that can be positioned for the proper cut and locked into place or an adjustable slide that changes the tension on an adjusting spring.

☐ 2. Loosen adjustment mechanism.

☐ 3. Insert conductor into stripping slot so that the wire is positioned with the length to be stripped extending beyond the stripping slot.

Note: For the initial adjustment, you should use a scrap piece of wire of the same diameter or position the wire so that a short (3/8-inch or 10-millimeter) section is stripped. When stripping wire for actual use, the length to be stripped will be determined by how the wire is to be used. The general rule is that the stripped area should fit fully into a connector or provide a complete wrap with the conductor insulation butting up against the conductor or positioned just outside the wrap.

☐ 4. Adjust jaws until you feel the jaw reach the conductor.

☐ 5. Readjust jaws to back off the conductor slightly.

☐ 6. Lock jaws into place.

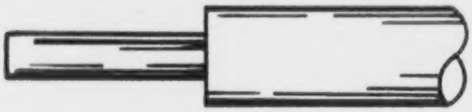
☐ 7. Squeeze stripper handles to hold jaws closed.

☐ 8. Pull wire from stripper.

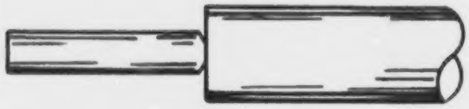
☐ 9. Examine conductor and insulation to evaluate adjustment.

Note: A proper adjustment will lead to a clean cut of the insulation and its separation without excessive pulling or a cut with jagged or stretched insulation. The conductor should be free of nicks or ring indentations from the stripping jaws. Stranded conductors should have all strands intact.

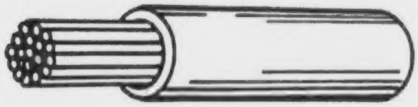
Figure 1: Examples



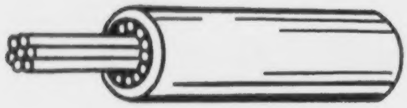
Good Cut



Nicked



Good Cut



Cut Strands

Job Sheet 2

☐ 10. If stripping is not satisfactory, repeat procedure to readjust and test adjustment.

☐ 11. Repeat procedure for other sizes and types of wires.

☐ 12. Return equipment and materials to their proper storage area.

Evaluator's comments:____

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Fabrication and Repair
Unit 3

Job Sheet 3—Cut and Strip Low-Voltage Wire and Cable

Name ______________________ Attempt Number __________

Date ______________________ Overall Rating __________

Evaluation criteria	**Rating**
• Procedure was followed correctly	______
• Correct strip lengths were determined and made	______
• Strips were free of nicks and cut strands	______
• Wire/cable lengths were correct	______

Introduction: Electronic products use various types of wire and cable designs in their fabrication. These different conductors must be cut and stripped using techniques and procedures that are suitable for their construction. This job sheet covers the cutting and stripping of the three most common types of wires and cables: single-conductor wire, multiple conductor cables, and twin-lead wire.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Wire strippers
- Wire cutters
- Utility knife
- Steel rule or tape measure
- Marker
- Various types of connectors
- Lengths of single-conductor wire
- Lengths of multiple conductor cables
- Lengths of twin-lead wire

B. Procedure for single-conductor wire

☐ 1. Use a connector, terminal, or other part or a data sheet to determine the correct length of wire to be stripped.

☐ 2. Measure and mark wire to indicate strip length.

Job Sheet 3

☐ 3. Using proper diameter stripper or correctly adjusted stripper, position the wire in the stripping slot, aligning the mark with the stripping slot.

☐ 4. Squeeze handles on strippers and pull off the insulation.

☐ 5. Examine wire and repeat procedure if required to obtain good strip.

☐ 6. Determine length of wire required.

Note: The conductor must be long enough to reach from one connection point to another with proper routing. The wire length may be indicated on the drawing, or the technician may have to measure to determine the wire length. In cases of complex wire routing, it may be easier to use the wire or a string to determine the length of wire required rather than trying to measure it. As a technique, some technicians prefer to go ahead and install the connector on the first end before determining the wire length so that the measurement will be more accurate in the event that some wire is lost in the installation of the connector.

☐ 7. Measure and mark the wire at the correct length.

☐ 8. Cut the wire.

☐ 9. Repeat Steps 1-5 to strip the wire as required for the connector or terminal to be installed on the second end of the wire.

☐ 10. Return equipment and materials to their proper storage location.

C. Procedure for multiple-conductor cable

☐ 1. Examine the end of the cable to determine its construction.

Note: As explained in the information sheet, there are several ways in which conductors are packaged as cables. These include: separately insulated wires that are joined by means of their insulation, separately insulated wires contained in an outer cable insulation, separate uninsulated conductors in a single cable insulation (such as twin-lead cable), shielded cables, ribbon cables, and coaxial cables. Twin-lead cables are covered in the next section of this job sheet. Ribbon cables and coaxial cables are covered in later job sheets.

☐ 2. Determine the length of wire to be stripped.

☐ 3. For cables with outer insulation, measure approximately three times the required strip length and mark the cable.

☐ 4. Use the utility knife to cut the outer insulation being careful not to cut the insulation of the individual wires.

☐ 5. If the insulation of the individual conductors is joined, use the utility knife to separate the individual wires to a distance approximately three times the required strip length being careful not to cut into the insulation of the individual wires.

Job Sheet 3

☐ 6. If the cable has shielding, separate the shielding strands enough to expose a length of each individual conductor approximately three times as long as the required strip length, being careful not to break off strands of the shielding.

☐ 7. Measure and strip each individual conductor as explained in Section B, procedure for single-conductor wire.

☐ 8. Determine length of cable required.

☐ 9. Measure and mark the cable at the correct length.

☐ 10. Cut the cable.

☐ 11. Repeat Steps 2-7 to strip the cable wires as required for the connectors or terminals to be installed on the second end of the cable.

☐ 12. Return equipment and materials to their proper storage location.

D. Procedure for twin-lead cable

☐ 1. Determine the length of wire to be stripped on each lead.

☐ 2. Measure and mark the cable approximately twice the length of the wire to be stripped.

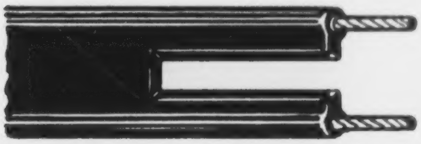
☐ 3. Using the utility knife, cut a long a straight line from the mark to the end of the cable approximately one-third of the cable width in from the outside of the cable.

☐ 4. Repeat Step 3 to cut another straight line approximately one-third of the cable width in from the other side of the cable.

☐ 5. Cut the insulation between the two long cuts and remove the insulation.

Note: The result should be a notch as shown in Figure 1.

Figure 1



☐ 6. Mark the two branches of the cable at the strip length.

☐ 7. Use the utility knife to cut the insulation at the mark on one branch being careful not to cut into the conductor.

☐ 8. Cut the insulation down to the conductor all the way around that branch until the insulation is loose.

Job Sheet 3

☐ 9. Pull the insulation from the conductor.

☐ 10. Repeat Steps 7-9 to remove the insulation from the other branch.

☐ 11. Determine length of cable required.

☐ 12. Measure and mark the cable at the correct length.

☐ 13. Cut the cable.

☐ 14. Repeat Steps 1-9 to strip the cable wires as required for the connectors or terminals to be installed on the second end of the cable.

☐ 15. Return equipment and materials to their proper storage location.

Evaluator's comments:____

Fabrication and Repair
Unit 3

Job Sheet 4—Install Coaxial Cable Connectors

Name ______________________ Attempt Number ______________

Date ______________________ Overall Rating ______________

Evaluation Criteria	**Rating**
• Procedure was performed correctly	________
• Stripped cable is suitable for connector installation	________
• Cable length is correct	________
• Connectors are correctly installed	________

Introduction: A special cable that is often used in the electronics industry is the coaxial cable, or coax as it is often called. Coax cable consists of one or more solid or stranded conductors that are wrapped in foam insulation. The inner conductor(s) are enclosed in a wire braid or spiral wrapped shielding that serves as a ground. All of this is encased by an outer insulation that also provides protection against the elements. There are strippers and connector crimpers designed especially for coaxial cable, and this job sheet describes their use. A technician should use coaxial tools if they are available.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Coaxial cable strippers
- Wire cutters
- Coaxial cable connector crimpers
- Coaxial cable
- Coaxial cable connectors
- Steel rule or tape measurer

B. Procedure

☐ 1. Examine end of coaxial cable and evaluate suitability for use.

Note: As with any cable, the exposed end of coaxial cable can become damaged or contaminated. Check the cable to see that the insulations are not damaged or separated, that the shielding is not damaged or bunched up, and that the conductor is in good condition, free from corrosion, and—for stranded conductors—free of broken strands.

Job Sheet 4

☐ 2. If the end of the cable is not usable, cut off enough of it to get rid of any defects.

☐ 3. Determine the length of cable to be stripped.

Note: Coaxial cables require specially designed connectors and do not use the variety of connectors that some other cables have available. Many coaxial cable strippers are designed so that positioning them at a given distance from the end of the cable will result in a properly stripped cable.

☐ 4. Mark location for positioning the strippers.

☐ 5. Slide the strippers over the end of the cable with the longer blade positioned nearer the end of the cable.

☐ 6. Squeeze the stripper handles and rotate the stripper around the cable until the cuts have been made around the entire cable.

☐ 7. Remove the strippers.

☐ 8. Pull the outer insulation off the end of the cable.

☐ 9. Slide the collar for the connector over the cable and past the area being stripped.

☐ 10. Unravel the shielding braid and fold it back over the outer insulation.

☐ 11. Pull the insulation off the conductor.

☐ 12. Slide the connector body over the end of the cable, feeding the conductor through the connector center hole and seating the connector against the outer insulation.

☐ 13. Slide the collar over the end of the connector and align it flush with the connector body.

☐ 14. Crimp the collar with a proper size coaxial cable crimping tool.

☐ 15. Determine length of cable required.

☐ 16. Measure and mark the cable at the correct length.

☐ 17. Cut the cable.

☐ 18. Repeat Steps 3-14 to strip the second end of the cable and install the connector.

☐ 19. Return equipment and materials to their proper storage location.

Job Sheet 4

Evaluator's comments: ____________________

Fabrication and Repair
Unit 3

Job Sheet 5—Install Ribbon Cable Connectors

Name ______________________ Attempt Number ______________

Date ______________________ Overall Rating ______________

Evaluation Criteria	Rating
• Procedure was done correctly	________
• Cut cable was suitable for connector installation	________
• Cable length was correct	________
• Connectors were properly installed	________

Introduction: Ribbon cables are used extensively in computers and with computer peripherals, such as printers. They provide the convenience of numerous conductors in a single cable, flexibility, and easy installation of connectors. Unlike other cables, ribbon cables even allow installation of connectors at points in the cable other than the ends. Because ribbon cable connectors pierce the insulation of the cable to contact the conductors, it is not necessary to strip the insulation.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Ribbon cable
- Wire cutters
- Ribbon cable connectors
- Screwdrivers or other tools necessary to install connectors
- Steel rule or tape measure

B. Procedure

☐ 1. Examine end of cable and ensure that the cut is straight and that the cable is not damaged.

☐ 2. If the end of the cable is not straight or if the cable is damaged, cut off enough cable to remove the damage and to provide a straight cut.

☐ 3. Determine the ground conductor on the ribbon cable.

Note: The ground conductor is normally on the outside edge of the ribbon cable and is normally colored differently from the rest of the cable.

Job Sheet 5

☐ 4. Determine the ground pin on the connector.

Note: If the ground pin of the connector is not marked on the connector, refer to a data sheet or other resource to determine which pin is the ground pin.

☐ 5. Separate inner and outer connector plates with a screwdriver.

☐ 6. Install the end of the cable into the connector body with the ground conductor aligned with the connector ground pin.

☐ 7. Push the cable through the connector so that approximately one-half inch of cable extends beyond the connector terminals.

☐ 8. Position the inner plate over the cable and slide it into the slots in the connector body.

☐ 9. Fold the excess cable over the inner plate and snap the outer plate into place over it.

☐ 10. Determine the length of the cable, allowing approximately one inch extra for each connector to be installed.

☐ 11. Cut the cable to length, leaving a square, smooth end.

☐ 12. Mark the location of other connectors to be installed.

Note: If connectors are to be installed at points over the length of the cable, be sure that the marked positions allow adequate length for each portion of the cable as it will be routed.

☐ 13. Repeat Steps 3-9 for other connectors to be installed.

☐ 14. Return equipment and materials to their proper storage area.

Evaluator's comments: ____

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Fabrication and Repair
Unit 3

Job Sheet 6—Install Crimp Connectors on Wire

Name ______________________ Attempt Number ______________

Date ______________________ Overall Rating ______________

Evaluation Criteria	**Rating**
• Procedures were done correctly	________
• Wire preparation was acceptable	________
• Correct tools were used	________
• Correct connectors were used	________
• Connector installations were acceptable	________

Introduction: While soldering provides good electrical and mechanical connections, it is often convenient to be able to disconnect electronic devices and circuits. For this reason, conductors are often fabricated with connectors on them. One of the most common types of single-conductor connectors is generally referred to as *terminal lugs*. Terminal lugs come in a variety of mating designs, but most share one of two installation methods. The terminal lug is installed on the conductor through the process called *crimping* or by soldering and, in some cases, by both crimping and soldering. This job sheet covers how to install connectors by crimping, while the next job sheet discusses soldering connectors to wires.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Crimp-type connectors
- Stranded wires and cables
- Stripping tools
- Crimping tools
- Utility knife
- Soldering iron and stand
- Solder
- Flux
- Wire gauge
- Steel rule or tape measure
- Isopropyl alcohol
- Clean cloth
- Acid brush

Job Sheet 6

B. Procedure

☐ 1. Determine gauge of wire to be used.

☐ 2. Select a suitable crimp connector.

Note: The connector must be suitable for the gauge of wire being used and for the type of terminal with which it must mate.

☐ 3. Determine the strip length required for the connector.

Note: The strip length will depend on the connector design. With some crimp connectors, the insulation should be flush with the end of the connector sleeve, while with other designs part of the connector is supposed to fit over the insulation.

☐ 4. Strip the wire.

☐ 5. Repeat Steps 1-3 for each conductor that is to receive a crimp connector.

☐ 6. If using stranded wire, tin the wire.

- Heat soldering iron to operating temperature.
- Gently twist the wire strands with your thumb and finger in the direction of the strand twist (usually clockwise) just enough to ensure that no strands are separated.
- Clean stripped portions of wires with alcohol and a clean cloth.
- Apply a small amount of flux to the area of the wire to be tinned.
- Hold the soldering iron against the wire for a few seconds.
- Touch solder to the hot wire and allow solder to flow over the wire strands in a thin, even coat.

  Note: The shapes of individual strands of wire can be seen through the solder in a well-tinned wire.
- Tin other wires as required.
- Clean tinned wires with alcohol and an acid brush.
- Inspect the wires to ensure that the wires are evenly coated, that solder has not wicked up under the insulation, that there is no bird-caging, and that the insulation is not burned or melted.
- Remove power from soldering equipment, unless required for other work.

☐ 7. Insert the wire into the sleeve of the connector, taking care to position the wire correctly with the end of the conductor fully seated in the connector and the wire insulation placed so that it is flush with the sleeve or in the sleeve as required.

Job Sheet 6

☐ 8. Select the correct crimping tool for the type and size connector being used.

Note: Crimp connector manufacturers generally make crimping tools to fit their connectors. For small connectors (wire gauge 10 and smaller), some standard sizes and styles of connectors and tools exist and a single tool may work on a variety of connector sizes. However, for larger wires and stranded cables, special tools or dies may be required, and, for very large connectors, hydraulic crimping may be required.

☐ 9. Position the crimping tool over the area of the connector to be crimped and squeeze the handle with enough pressure to fold the crimp tabs over completely or to fully indent the crimp area.

☐ 10. If necessary, reposition the crimp tool and crimp other tabs or crimp areas on the same connector.

☐ 11. Once the crimp is complete, gently tug the wire to make sure that it is securely held in the connector.

☐ 12. Inspect the crimp to ensure that the crimp tabs are fully seated and properly aligned, that the wire is fully seated, and that the insulation is positioned correctly with regard to the connector.

☐ 13. Repeat Steps 7-12 for remaining crimps to be done.

☐ 14. Determine the wire length and cut to length.

☐ 15. Repeat Steps 1-13 for connectors to be installed at the other end of the wire.

☐ 16. Return equipment and materials to their proper storage area.

Evaluator's comments:____

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Fabrication and Repair
Unit 3

Job Sheet 7—Install Soldered Connectors on Wires

Name ______________________________ Attempt Number __________

Date ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
• Procedures were done correctly	________
• Wire preparation was acceptable	________
• Solder joints were acceptable	________
• Installation of connector was acceptable	________

Introduction: Crimping is not normally used on solid conductors, which generally use soldered connectors. Some connectors must be soldered during installation. This is a also a common practice in electronic installations to ensure a good electrical bond and to protect connections from corrosion. Some connectors require both soldering and crimping, while others require only soldering. This job sheet covers examples of both types.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Solid and stranded single-conductor wire
- Multiple conductor cable or shielded cable
- Spade lugs that require soldering and crimping and that fit wire used
- Two-terminal plugs or multi-pin connectors suitable for cable used
- Wire cutters
- Wire strippers
- Crimping tools
- Soldering iron and stand
- Solder
- Flux
- Isopropyl alcohol
- Cloth
- Acid brush

B. Procedure to install spade lugs

☐ 1. Turn on soldering iron and allow it to reach operating temperature.

☐ 2. Select correct connector for size of wire and type of connection being made.

Job Sheet 7

☐ 3. Strip wire to fit the connector.
☐ 4. If using stranded wire, twist and tin strands.
☐ 5. Insert wire into connector sleeve and seat it properly.
☐ 6. Hold the soldering iron to the sleeve for a few seconds.
☐ 7. Touch solder to the heated wire inside the sleeve and allow the solder to flow over the wire and contact the sides of the sleeve.
☐ 8. Clean the solder joint with alcohol and a cloth or acid brush.
☐ 9. Inspect the solder joint.
☐ 10. If the joint is acceptable, continue the procedure; otherwise, desolder the joint by applying heat to it, removing the wire, and reaccomplishing Steps 5-9.
☐ 11. Crimp the crimp portion of the connector and check for a good crimp.
☐ 12. Determine correct wire length and cut to length.
☐ 13. Repeat Steps 2-11 as necessary for the other end of the wire or other conductors.
☐ 14. Remove power from the soldering iron.
☐ 15. Return equipment and materials to their proper storage area.

C. Procedure to install solder jacks and connectors

☐ 1. Turn on soldering iron and allow it to reach operating temperature.
☐ 2. Select correct cable for type of connector being used.
☐ 3. Strip wire to fit the connector.
☐ 4. If using stranded wire, twist and tin strands.
☐ 5. Disassemble connector as necessary to allow installation.

Note: Many connectors that require soldered installation have a body or shell that must be taken apart and placed over the cable. Generally, the shell will unscrew from the plug or connector and the connector body may require removal of fasteners or may snap apart.

☐ 6. Slide the connector shell or body over the cable as necessary.

Job Sheet 7

☐ 7. Strip the cable and individual conductors.

Note: The amount to be stripped will vary with the connector but three primary considerations are:

- Is enough conductor exposed to allow proper installation on the connector terminals?
- Is the stripped area short enough that exposed conductors do not extend beyond the body or shell of the connector?
- Are the conductors inside the connector body or shell short enough and routed so that there is no danger of them contacting each other?

☐ 8. If the cable uses stranded wires, twist them slightly and tin them.

☐ 9. If the cable has shielding that is used for a ground, gather the strands together and treat them as a stranded wire, twisting and tinning them.

☐ 10. Hold conductor end to terminal and heat both with the soldering iron.

Note: If the connector uses terminals that require partial mechanical installation, such as bifurcated, turret, or hook terminals, study the procedures in later job sheets to see how these terminals are soldered.

☐ 11. Touch solder to the joint and allow it to flow evenly over the wire and terminal where they join, using only as much solder as required to make an electrically and mechanically sound joint.

☐ 12. Clean the solder joint with alcohol and a cloth or acid brush.

☐ 13. Inspect the solder joint.

☐ 14. If the joint is acceptable, continue the procedure; otherwise, desolder the joint by applying heat to it, removing the wire, and reaccomplishing Steps 10-13.

☐ 15. Repeat Steps 7-14 for other conductors.

☐ 16. Determine correct cable length and cut to length.

☐ 17. Repeat Steps 3-9 as necessary for the other end of the cable.

☐ 18. Determine which conductors go to which terminals.

Note: In some cases, such as a single-conductor shielded cable or cables with color-coded wires, this may be obvious. However, when working with some multiple-conductor cables, it may be necessary to check for continuity through the cable. Touch one probe of an ohmmeter or multimeter configured to test resistance to a pin on the installed connector and the other probe to an exposed conductor at the other end of the cable. An infinite reading indicates that there is no circuit, while a zero or numerical reading shows a circuit, meaning that the connector pin and tested conductor are opposite ends of the same wire.

Job Sheet 7

☐ 19. Repeat Steps 10-15 to solder each conductor to the appropriate connector terminal.

☐ 20. Remove power from the soldering iron.

☐ 21. Return equipment and materials to their proper storage area.

Evaluator's comments:____

Fabrication and Repair
Unit 3

Job Sheet 8—Solder Wires to Turret Terminals and Desolder Wires

Name ______________________ Attempt Number ______________

Date ______________________ Overall Rating ______________

Evaluation Criteria	**Rating**
• Procedures were done correctly	________
• Forming of wire leads was acceptable	________
• Solder joints were acceptable	________
• Desoldering results were acceptable	________

Introduction: A common way of connecting wires to a printed circuit board is to use turret terminals. Turret terminals provide an easily accessible terminal and also allow several circuits to be joined at a common point. The technician doing a turret terminal connection has several options about how to wrap, install, and solder the conductors. Some of these options may be clarified in an organization's workmanship standards, so you should check with your instructor or with published standards to determine how to address some of these options.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Soldering iron and stand
- Soldering vise
- Wire strippers
- Long-nose pliers
- Solder
- Flux
- Isopropyl alcohol and clean cloth
- Acid brush
- Solder sucker
- Circuit board with two turret terminals installed
- Two 6-inch lengths of 22-gauge wire

B. Procedure to solder wires to turret terminals

☐ 1. Turn on soldering iron and allow it to reach operating temperature.

☐ 2. Secure circuit board in soldering vise.

Job Sheet 8

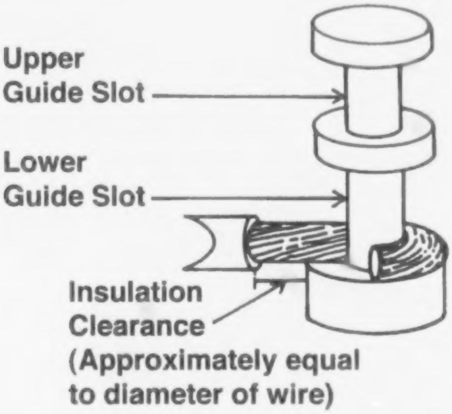
☐ 3. Strip the wire so that the length of the exposed end is approximately 4-5 times the diameter of the narrow part of the terminal post.

☐ 4. Tin the wire.

☐ 5. Use long-nose pliers to form the end of the wire around the lower slot on the turret terminal.

Note: The wire should contact a minimum of one-half of the turret post circumference (180°) as shown in Figure 1. Some workmanship standards or drawings may specify a greater amount of contact. The insulation on the wire should not contact the terminal and is normally positioned so that there is a distance approximately equal to the diameter of the wire between the insulation and the terminal.

Figure 1


Upper Guide Slot
Lower Guide Slot
Insulation Clearance (Approximately equal to diameter of wire)

☐ 6. Lightly coat the wire and area of turret to be soldered with flux.

☐ 7. Touch soldering iron to wire and terminal to allow them to heat for a few seconds.

☐ 8. Touch the solder to the connection and allow solder to flow between the turret and wire, coating the wire, and making a smooth connection between the straight and hooked portions of the wire.

☐ 9. Clean connection with alcohol and a clean cloth or the acid brush.

☐ 10. Inspect the connection; touch up or redo solder joint as required.

Note: If the solder joint must be redone, see Section C, Procedures to desolder turret terminal connection, below.

Job Sheet 8

☐ 11. Reaccomplish Steps 3-10 to attach the other end of the wire to the lower slot on the other turret terminal.

☐ 12. Reaccomplish Steps 3-10 to attach the other wire to the top slot of each turret terminal.

C. Procedure to desolder turret terminal connection

☐ 1. Use soldering iron to melt solder on connection.

☐ 2. Push or pry wire off terminal.

☐ 3. Apply soldering iron to any remaining solder on conductor and terminal and use solder sucker to pull melted solder away from parts.

☐ 4. Clean conductor and terminal with alcohol.

☐ 5. If conductor is to be reinstalled, accomplish applicable steps of Section B, Procedure to solder wires to turret terminals.

☐ 6. If task is complete, return equipment and materials to their proper storage area.

Evaluator's comments: ____

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Fabrication and Repair
Unit 3

Job Sheet 9—Splice Wires Together By Means of Crimping

Name ______________________ Attempt Number ______________

Date ______________________ Overall Rating ______________

Evaluation Criteria	**Rating**
• Procedure was done correctly	______
• Wire preparation was acceptable	______
• Crimping sleeve was correctly installed	______
• Crimped splice was acceptable	______

Introduction: It is sometimes necessary to joint two or more wires together in a process called *splicing*. There are two common methods for splicing wires: crimping and soldering. The choice between these two methods is generally a matter of preference or available materials as both methods normally provide acceptable electrical and mechanical bonds. In some specific installations, one or the other may offer an advantage, such as a better environmental seal or a more pleasing appearance. This job sheet describes how to make a crimp splice, while Job Sheet 10 provides the procedure for a soldered splice.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Two pieces of wire
- Crimping sleeve to fit wire
- Crimping tool
- Wire cutters
- Wire strippers
- Soldering iron and stand (if tinning is required)
- Solder (if tinning is required)

B. Procedure

☐ 1. If tinning is required, turn on soldering iron and allow it to reach operating temperature.

☐ 2. Strip wires to length specified in crimping sleeve data sheet or to a length approximately one-third the length of the crimping sleeve.

☐ 3. If using stranded wire, twist and tin the exposed ends, turning off the soldering equipment once the tinning is complete.

Job Sheet 9

☐ 4. Insert one wire in one end of the crimping sleeve and the other wire in the opposite end of the crimping sleeve.

☐ 5. Position the wires so that the end of each wire is visible in the crimping sleeve window and the insulation goes into the ends of the crimping sleeve barrel.

☐ 6. Crimp one side of the crimping sleeve and verify that both wires are still visible in the window.

☐ 7. Crimp the other side of the crimping sleeve.

☐ 8. Verify that the crimp is good by pulling gently on the two wires and visually inspecting the crimp and verifying that the wires are visible in the window.

☐ 9. Return equipment and materials to their proper storage area.

Evaluator's comments: ____

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Fabrication and Repair
Unit 3

Job Sheet 10—Splice Wires Together by Means of Soldering

Name ______________________ Attempt Number ______________

Date ______________________ Overall Rating ______________

Evaluation Criteria	**Rating**
• Procedure was done correctly	________
• Wire preparation was acceptable	________
• Wire twist was acceptable	________
• Solder joint was acceptable	________
• Shrink tubing installation or taping was acceptable	________

Introduction: A soldered connection may be preferable to a crimped connection in some installation, such as the splicing of wires of different diameters or splicing two conductors to a third where the use of a crimping sleeve would not provide an acceptable seal. This job sheet describes two soldering methods, one for two wires of the same diameter and one for wires of different diameters or splicing more than two wires.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Four pieces of wire with two pieces the same diameter and two pieces of different diameters
- Electrical tape
- Shrink tubing to fit wires of the same diameter
- Heat gun
- Wire cutters
- Wire strippers
- Soldering iron and stand
- Solder
- Pliers

B. Procedure for splicing two wires of the same diameter

☐ 1. Turn on soldering iron and allow it to reach operating temperature.

☐ 2. Strip approximately 1 inch of insulation from the end of one wire to be spliced and approximately 2 inches of insulation off the other wire.

Job Sheet 10

☐ 3. Tin the ends of the wires, twisting the ends of stranded wire before tinning.

Note: The wires need to be tinned whether or not they are stranded in order to prepare them to be soldered to each other.

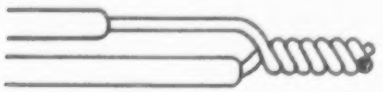
☐ 4. Cut a piece of shrink tubing and slide it over the end of one of the wires to be spliced.

Note: The shrink tubing should be long enough to allow it to fit over the splice while extending at least one-quarter inch over the insulation of each wire. If the unspliced end of one wire will allow the installation of shrink tubing over it, you can wait until the wires have been soldered before cutting and placing the shrink tubing to ensure a good fit.

☐ 5. Lay the wires with the ends to be spliced next to each other.

☐ 6. Use pliers to twist the wires together, continuing to twist until both wires have approximately three-quarters of an inch of twist.

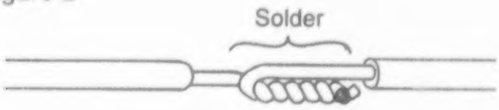
Figure 1



☐ 7. Bend the wire with the longer stripped area over the twisted joint.

☐ 8. Solder the length of the twisted joint to coat the twisted wires and the laid-over section of the wire with the longer stripped area.

Figure 2



☐ 9. Position the shrink tubing over the splice, ensuring that it overlaps the insulation of each wire by at least one-quarter inch.

☐ 10. Use the heat gun to apply heat to the tubing, moving the heat gun slowly without touching the shrink tubing so that the tubing draws up slowly and evenly over the splice with a snug fit on the ends.

☐ 11. If task is complete, return equipment and materials to their proper storage location.

Job Sheet 10

C. Procedure for splicing two wires of different diameters or more than two wires

☐ 1. Turn on soldering iron and allow it to reach operating temperature.

☐ 2. Strip approximately 1 inch of insulation from the end of one wire to be spliced and approximately 2 inches of insulation off the other wire(s).

Note: If the wires are different diameters, use the largest wire as the one from which 1 inch of insulation is stripped.

☐ 3. Tin the ends of the wires, twisting the ends of stranded wire before tinning.

Note: The wires need to be tinned whether or not they are stranded in order to prepare them to be soldered to each other.

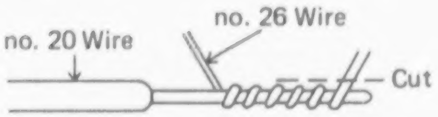
☐ 4. If the wires are the same size, wrap the wires together and solder them using the method described in Section B, Steps 5 and 6.

Note: For multiple wires, the conductors can be wrapped in pairs and then wrapped together. However, splices of more than four wires become difficult to handle and another method, such as a terminal block, should be considered over splices.

☐ 5. If the wires are different sizes:

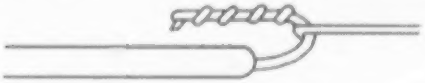
- Lay the two stripped areas near each other with the insulation approximately one-fourth inch apart and the smaller wire at approximately a 60-degree angle to the larger wire.
- Wrap the smaller conductor around the larger one.
- Cut any protruding end from the smaller wire.

Figure 3



- Solder the twisted section of the wires.
- Bend the soldered section back over the larger wire so that approximately half its length is over the insulation of the larger wire.

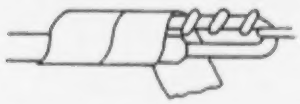
Figure 4



Job Sheet 10

☐ 6. Once the joint has be soldered and positioned in accordance with either Step 4 or 5, wrap the splice with electrical tape, beginning on an insulated area at least one-half inch beyond any conductor and wrapping the tape in spirals that overlap each other by approximately half the width of the tape and continuing to the insulation on the other wire and at least one-half inch beyond any conductor.

Figure 5



☐ 7. If task is complete, return equipment and materials to their proper storage location.

Evaluator's comments:

Fabrication and Repair
Unit 3

Job Sheet 11—Install Components Using Mechanical Fasteners

Name ______________________ Attempt Number ______________

Date ______________________ Overall Rating ______________

Evaluation Criteria	**Rating**
• Correct fasteners were selected	________
• Correct tools were used	________
• Installation procedures/specifications were correctly followed	________
• Installation is acceptable	________

Introduction: The three most common types of mechanical fasteners used for installing electrical components are threaded fasteners (such as screws and bolts), rivets, and locking mechanisms that are part of the component design (such as tabs, sockets, and latches). In many cases, the components will include installation instructions that describe how to install them. This job sheet will allow you to practice installing and removing components commonly used in your facility that are secured with mechanical fasteners.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Various components that are installed with mechanical fasteners
- Rivet gun and rivets
- Circuit boards into which the components can be installed
- Hand tools required for installing components

B. Procedure

☐ 1. Select component to be installed.

☐ 2. Identify location for installation.

☐ 3. Determine type of mechanical fastener required for installation, including number of fasteners and size as applicable.

☐ 4. Determine tools required for installation.

☐ 5. Review specifications and instructions for types of tools and fasteners to be used.

Job Sheet 11

☐ 6. Obtain necessary fasteners and tools.

☐ 7. Position component with correct orientation at installation site.

Note: Most circuit boards are designed so that installation holes, alignment pins, and other installation aids are present as required. However, in some cases, it may be necessary to drill holes, install inserts, or make other modifications to the circuit board to allow installation of components.

☐ 8. Install fasteners to secure component.

☐ 9. Verify successful installation through inspection and testing.

☐ 10. If task is complete, return equipment and materials to their proper storage location.

Evaluator's comments:____

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Fabrication and Repair
Unit 3

Job Sheet 12—Install Components Using Swaging

Name ______________________ Attempt Number ______________

Date ______________________ Overall Rating ______________

Evaluation Criteria	**Rating**
• Correct component was selected	________
• Proper tool was selected	________
• Tool was properly configured	________
• Procedure was done correctly	________
• Swaged installation was acceptable	________

Introduction: *Swaging* is a process of deforming metal through pressure. The installation of a rivet is a type of swaging. But swaging has other uses in the electronics industry. Turrets, posts, pins, and other components are sometimes installed through swaging. Generally, swaging requires the use of a press that provides the pressure required to deform the component. The press may be hand-operated or powered by electricity or air.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Component that is installed through swaging
- Swaging equipment
- Circuit board into which swaged component can be installed

B. Procedure

☐ 1. Review specifications or data sheet for swage component.

☐ 2. If using power swaging equipment, start up the system per the operating manual.

☐ 3. Set up swaging equipment as required for the component and fasteners.

Note: Set may include, but is not limited to, installation of a press die and/or receiving die, pressure settings, distance adjustments, etc.

☐ 4. Position component on circuit board to allow installation.

Job Sheet 12

☐ 5. Position circuit board in swaging equipment and align press head with swage component.

☐ 6. Operate swaging equipment to install component or fastener.

☐ 7. Examine swaged part to verify that installation is satisfactory.

Note: The swaged part should be straight, fully seated, and correctly deformed to provide a secure installation.

☐ 8. If swaged part is not properly installed, remove the part and repeat Steps 3-7, readjust the equipment as necessary to obtain an acceptable installation.

☐ 9. Repeat Steps 1-8 for remaining parts to be swaged.

☐ 10. If task is complete, return equipment and materials to their proper storage location.

Evaluator's comments:____

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Fabrication and Repair
Unit 3

Job Sheet 13—Tin and Form Leads on Through-Hole Components

Name ______________________ Attempt Number ______________

Date ______________________ Overall Rating ______________

Evaluation Criteria	**Rating**
• Correct components were selected	________
• Lead forming is acceptable	________
• Tinning of leads is acceptable	________

Introduction: The most common type of component used in printed circuit boards are through-hole components. The name of these components is derived from the fact that the leads of such components go through holes in the circuit boards and are soldered into the holes. Knowledge on how to install through-hole components is important to those who build or repair electronic assemblies, while those who design electronic equipment need to understand the capabilities and limitations of through-hole technology.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Through-hole components
- Circuit boards designed to receive the through-hole components used
- Soldering iron and stand
- Soldering vise
- Solder
- Flux
- Isopropyl alcohol and cloth
- Acid brush
- Lead-forming tools
- Lead-forming dies
- Steel rule

B. Procedure

☐ 1. Turn on soldering iron or tinning pot and allow to reach operating temperature.

☐ 2. Identify components to be installed.

☐ 3. Review drawings or data sheets to determine lead forming requirements.

☐ 4. Obtain lead-forming tools and dies as required to shape component leads.

Job Sheet 13

☐ 5. If forming leads with hand tools:

- Measure the length of the lead between the component and the first bend radius.
- Use long-nose pliers to bend the lead to the approximate radius requirement.
- Measure and form other bends for stress relief and positioning as required by the assembly drawing or component data book.
- Repeat process as required for other leads.

☐ 6. If forming leads with templates or dies:

- Select correct template or die.
- Insert component in template or die.
- Apply pressure to deform leads to template or die shape.
- Hand form any additional lead-forming required by the drawing or data sheet that is not accomplished by the template or die.
- Repeat process as required for other components.

☐ 7. Tin component leads.

☐ 8. Turn off soldering iron or tinning pot.

☐ 9. If task is complete, return equipment and materials to their proper storage location.

Evaluator's comments: ______________________________

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Fabrication and Repair
Unit 3

Job Sheet 14—Install Through-Hole Components on a Circuit Board

Name ____________________________________ Attempt Number __________

Date ____________________________________ Overall Rating __________

Evaluation criteria	**Rating**
• Correct components were loaded	________
• Components are in correct location and correctly oriented	________
• Through-hole leads were correctly prepared	________
• Solder joints are correct for type of hole and component	________
• Soldering is acceptable	________
• Board is adequately clean	________

Introduction: Most electronic devices contain circuit boards and soldered components. For those circuit boards to work properly, they must contain the correct components, correctly installed, and secured with acceptable solder joints. Next to component failures, solder joint defects is a major contributor to equipment failures. Thus, those who build and repair electronic devices need to know how to load and solder circuit boards.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A Equipment and materials

- Soldering iron and stand
- Soldering vise
- Solder
- Flux
- Isopropyl alcohol and cloth
- Acid brush
- Component insertion tools
- Component spacers
- Circuit board
- Circuit components and materials as required by drawing
- Circuit drawing

Job Sheet 14

B. Procedure

☐ 1. Load components in circuit board, ensuring that components are placed in the correct position on the proper side of the circuit board and that polarity-sensitive and grounded components are correctly oriented.

Note: During the circuit board fabrication process, component loading may be done in stages. For example, a circuit board may be wave soldered. In that case, some components may not be loaded initially, due to sensitivity to the heat of wave soldering or because of their tendency to pick up excessive solder. For circuit boards with components loaded on both sides, one side at a time may be loaded.

☐ 2. Position components to provide correct clearance between component and circuit board.

Note: Some components may be *flush-mounted*—that is, allowed to rest against the circuit board. Other components may require a clearance between them and the circuit board that is provided by the way the leads are formed or through the use of spacers placed between the component and the circuit board until the components have been soldered.

☐ 3. Shape the leads as necessary where they pass through the circuit board.

Note: Depending on the soldering technique to be used and the assembly requirements, the leads may be left as they are and clipped after soldering or they may be clinched, semi-clinched, swaged, or clipped prior to soldering.

☐ 4. Turn on soldering iron and allow it to reach operating temperature.

☐ 5. Determine the heat sensitivity of the parts.

Note: If any of the parts are subject to damage at soldering temperatures, use a heat sink when soldering.

☐ 6. Determine the type of solder joint to be made for each lead.

Note: The type of solder joint will depend primarily on the types of holes in the circuit board (unsupported, through connector, or eyelet), the requirements for finishing the lead, and workmanship standards.

☐ 7. Solder the component leads using short touch times and a minimum amount of solder.

☐ 8. Inspect and touch up solder joints as you proceed.

☐ 9. Cut off leads flush with solder joints.

Job Sheet 14

☐ 10. Touch the soldering iron near each clipped lead to cause the solder to *reflow* to cover the clipped ends of the leads.

☐ ☐ 11. If assembling a circuit board with components loaded on both sides, repeat Steps 1-10 to load and solder the components on the second side.

☐ 12. Turn off soldering iron once assembly is complete.

☐ 13. Clean the board using alcohol and a clean cloth or equipment such as a vapor degreaser or aqueous cleaning system.

☐ 14. If task is complete, return equipment and materials to their proper storage location.

Evaluator's comments: ______________________________

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Fabrication and Repair
Unit 3

Job Sheet 15—Install Surface-Mount Components on a Circuit Board

Name ______________________________ Attempt Number __________

Date ______________________________ Overall Rating __________

Evaluation criteria	Rating
• Correct components were loaded	________
• Components are in correct location and correctly oriented	________
• Installation areas were correctly prepared	________
• Solder joints are correct for type of lead and component	________
• Soldering is acceptable	________
• Board is adequately clean	________

Introduction: The use of surface-mount components is growing in popularity among electronic equipment manufacturers and designers. This trend is likely to continue due to the small packages of powerful components available in this type of package. Electronic technicians need to know how to install surface-mount components and to fabricate circuit boards that use this type of component. While many surface-mount components require the use of automated processes for their lead-forming and installation, numerous surface-mount components can be installed using manual methods.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Surface-mount components
- Surface-mount circuit board
- Solder paste as required
- Soldering iron with tip suitable for surface-mount components and holder
- Solder of diameter and type suitable for surface-mount components
- Lead-forming dies

Job Sheet 15

B. Procedure

☐ 1. Select components as required for assembly.

☐ 2. Lead form components as required.

Note: Because of the fine pitches used with surface-mount components, lead-forming is often done by machines or by the manufacturer or by companies that specialize in such precision lead-forming.

☐ 3. Determine installation method.

Note: The three primary methods of surface-mount component installation are hand-soldering, wave-soldering, and reflow, which involves the use of a solder paste that is normally baked to harden in an infrared or other type "oven." The choice of installation method is based on the specific component and lead design, the board design, and facility capabilities.

☐ 4. If solder paste or other adhesives are to be used, apply bonding agent to installation area.

☐ 5. Position component at installation area, ensuring that component is correctly oriented for polarity and grounding and that leads are aligned with terminals.

☐ 6. Solder leads, taking care not to short between leads if hand-soldering is used.

☐ 7. Inspect work and touch up as necessary.

☐ 8. Turn off soldering equipment.

☐ 9. Clean circuit board.

Note: Some surface-mount component manufacturers recommend cleanliness testing for circuit boards using surface-mount technology because of the possibility of contaminants getting caught in the fine leads.

☐ 10. If task is complete, return equipment and materials to their proper storage location.

Evaluator's comments: ____

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Fabrication and Repair
Unit 3

Job Sheet 16—Remove Through-Hole Components from a Circuit Board

Name ______________________ Attempt Number ______________

Date ______________________ Overall Rating ______________

Evaluation Criteria	Rating
• Correct procedures were followed	________
• Component was successfully removed	________
• No unnecessary damage occurred	________
• Circuit board and component were adequately cleaned	________

Introduction: Components may have to be removed from a circuit board for any of several reasons. The two most common are that a component has failed or that it is being exchanged for a component with different characteristics, such as a higher operating temperature, a longer operating life, a different resistance value, increased memory capacity, etc. Similarly, there are several methods for removing through-hole components. Each has its advantages and disadvantages for any particular case. For example, the leads of a component can be clipped and the solder removed. This is a quick and easy method, but it means that the component may have to be scrapped. As you study this job sheet, consider the uses of each method described.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Note: This job sheet describes the use of various methods for removing components. Some facilities may have special desoldering workstations that have special equipment not described here. Discuss the use of such equipment with your instructor.

A. Equipment and materials

- Circuit board with through-hole components to be removed
- Soldering iron and holder
- Solder wick
- Solder sucker
- Flux
- Hot plate
- Wire cutters
- Long-nose pliers
- Isopropyl alcohol and clean cloth
- Heat sink

Job Sheet 16

B. Procedure with leads clipped

Note: If the component is known to be defective and must be replaced, this method is not only quick and easy but greatly reduces the chances of damaging other components or lifting pads.

☐ 1. Turn on soldering iron and allow it to heat up to operating temperature.

☐ 2. Identify the component to be removed.

☐ 3. Use wire cutters to cut the leads on the component.

☐ 4. Remove the component and dispose of it.

☐ 5. Apply flux to lead to be removed.

☐ 6. Heat the solder in one through-hole and remove the lead using long-nose pliers once the solder is liquid enough to allow the lead to be easily removed.

☐ 7. Use a solder sucker or soldering wick to remove solder from the pad and through-hole.

☐ 8. Repeat Steps 5 and 6 to remove remaining leads.

☐ 9. Turn off power to soldering iron.

☐ 10. Clean area that was desoldered.

☐ 11. Return equipment and materials to their proper storage area.

C. Procedure using soldering iron without clipping leads

Note: Many electronic components are expensive or difficult to obtain. For those reasons, if a component to be removed is still functional, the technician should try to remove the component without damaging it. This procedure is used to minimize damage to the component.

☐ 1. Turn on soldering iron and allow it to heat up to operating temperature.

☐ 2. Identify the component to be removed.

☐ 3. Apply solder to the area to be desoldered.

☐ 4. Heat the solder around a lead on the component and use a solder sucker to remove the solder as it melts.

Caution: Limit the time that the soldering iron touches the joint to a few seconds to avoid overheating the component. For further protection, you can place a heat sink on the lead between the component and the soldering point. The use of a heat sink increases the possibility of lifting the pad, but that may be an acceptable risk if the circuit board must be scrapped anyway.

Job Sheet 16

☐ 5. Repeat Step 3 for other leads until the component is free.

☐ 6. Remove the component.

☐ 7. Use the soldering iron and solder sucker to remove any solder remaining on the component leads.

☐ 8. Clean the component leads with alcohol and store in a proper location.

☐ 9. Repeat Steps 2-7 for other components to be removed.

☐ 10. If the circuit board is to be reused, remove any remaining solder from the through-holes and pads by using the soldering iron and flux with a solder sucker or solder wick as required.

☐ 11. Turn off power to soldering iron.

☐ 12. Clean area that was desoldered.

☐ 13. Return equipment and materials to their proper storage area.

D. Procedure using additional heat source

Note: This method is particularly useful for removing a component that has many leads and for removing components on circuit boards that have internal heat sinks. The two options are to use a method that directs heat at the component or provide a general source of heat to the board. The latter method is especially useful if there is no need to save the circuit board or other components.

☐ 1. Turn on soldering iron and allow it to heat up to operating temperature.

☐ 2. Identify the component to be removed.

☐ 3. Direct heat over the component or heat the circuit board with a hot plate.

☐ 4. Heat the solder around a lead on the component and use a solder sucker to remove the solder as it melts.

☐ 5. Repeat Step 4 for other leads until the component is free.

☐ 6. Remove the component.

☐ 7. Use the soldering iron and solder sucker to remove any solder remaining on the component leads.

☐ 8. Clean the component leads with alcohol and store in a proper location.

☐ 9. Repeat Steps 2-8 for other components to be removed.

☐ 10. If the circuit board is to be reused, remove any remaining solder from the through-holes and pads by using the soldering iron and flux with a solder sucker or solder wick as required.

Job Sheet 16

☐ 11. Turn off power to soldering iron and additional heat source.
☐ 12. Clean area that was desoldered.
☐ 13. Return equipment and materials to their proper storage area.

Evaluator's comments:______________________________

Fabrication and Repair
Unit 3

Job Sheet 17—Remove Surface-Mount Components from a Circuit Board

Name ______________________ Attempt Number __________

Date ______________________ Overall Rating __________

Evaluation criteria	**Rating**
- Correct procedures were followed	______
- Component was successfully removed	______
- No unnecessary damage occurred	______
- Circuit board and component were adequately cleaned	______

Introduction: Surface-mount components can present a different set of problems than through-hole components when it comes to removing them. First, solder is on the same side of the circuit board as the components, which can make it easier to damage the component. Further, heat may be applied directly to the pad, which can lead to more lifted pads. The leads and pads on surface-mount components are often more delicate than those used with through-hole components. The use of solder pastes may complicate the removal process. The one factor that can sometimes prove to be an advantage is that surface-mount components are generally installed with less solder.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Note: This job sheet describes the use of various methods for removing components. Some facilities may have special desoldering workstations that have special equipment not described here. Discuss the use of such equipment with your instructor.

A. Equipment and materials

- Circuit board with surface-mount components to be removed
- Soldering iron and holder
- Solder wick
- Solder sucker
- Hot plate
- Hot air source and nozzles
- Wire cutters
- Tweezers
- Isopropyl alcohol and clean cloth
- Heat sink

Job Sheet 17

B. Procedure with leads clipped

Note: If the component is known to be defective and must be replaced, this method is easy for surface-mount components with exposed leads, though it is often just as quick to desolder the leads without clipping them.

☐ 1. Turn on soldering iron and allow it to heat up to operating temperature.

☐ 2. Identify the component to be removed.

☐ 3. Use wire cutters to cut the leads on the component.

☐ 4. Remove the component and dispose of it.

☐ 5. Heat the solder on a terminal or group of terminals and remove the lead(s) using tweezers once the solder is liquid enough to allow the lead(s) to be easily removed.

☐ 6. Use a solder sucker to remove solder from the pad.

☐ 7. Repeat Steps 5 and 6 to remove remaining leads.

☐ 8. Turn off power to soldering iron.

☐ 9. Clean area that was desoldered.

☐ 10. Return equipment and materials to their proper storage area.

C. Procedure using soldering iron without clipping leads

☐ 1. Turn on soldering iron and allow it to heat up to operating temperature.

☐ 2. Identify the component to be removed.

☐ 3. Heat the solder around a lead or group of leads on the component and use a solder sucker to remove the solder as it melts.

Caution: Limit the time that the soldering iron touches the leads to a few seconds to avoid overheating the component.

☐ 4. Repeat Step 3 for other leads until the component is free.

Note: For some fine-pitched components, the use of solder wick provides a convenient way to remove the solder.

☐ 5. Remove the component.

☐ 6. Use the soldering iron and solder sucker to remove any solder remaining on the component leads.

☐ 7. Clean the component leads with alcohol and store in a proper location.

☐ 8. Repeat Steps 2-7 for other components to be removed.

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Job Sheet 17

☐ 9. If the circuit board is to be reused, remove any remaining solder from the pads by using the soldering iron and flux with a solder sucker or solder wick as required.

☐ 10. Turn off power to soldering iron.

☐ 11. Clean area that was desoldered.

☐ 12. Return equipment and materials to their proper storage area.

D. Procedure using additional heat source

Note: This method is particularly useful for removing a component that has many leads and for removing components on circuit boards that have internal heat sinks. The two options are to use a method that directs heat at the component or provide a general source of heat to the board. The latter method is especially useful if there is no need to save the circuit board or other components.

☐ 1. Turn on soldering iron and allow it to heat up to operating temperature.

☐ 2. Identify the component to be removed.

☐ 3. Direct heat over the component or heat the circuit board with a hot plate.

☐ 4. Heat the solder around a lead or group of leads on the component and use a solder sucker to remove the solder as it melts.

☐ 5. Repeat Step 4 for other leads until the component is free.

☐ 6. Remove the component.

☐ 7. Use the soldering iron and solder sucker to remove any solder remaining on the component leads.

☐ 8. Clean the component leads with alcohol and store in a proper location.

☐ 9. Repeat Steps 2-8 for other components to be removed.

☐ 10. If the circuit board is to be reused, remove any remaining solder from the pads by using the soldering iron and a solder sucker or solder wick as required.

☐ 11. Turn off power to soldering iron and additional heat source.

☐ 12. Clean area that was desoldered.

☐ 13. Return equipment and materials to their proper storage area.

Job Sheet 17

Evaluator's comments:____

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Fabrication and Repair
Unit 3

Job Sheet 18—Repair a Printed Circuit Board

Name ______________________ Attempt Number ______________

Date ______________________ Overall Rating ______________

Evaluation Criteria	Rating
• Repair requirement was correctly identified	________
• Correct procedures were followed	________
• Workmanship of repair was acceptable	________
• Repair was functional	________

Introduction: Circuit boards may require repair due to failed components, defects in the circuit board, or a need to change the circuitry on the board. While an electronics technician may be limited in the repairs that can be made, this job sheet covers a number of procedures that may prove useful in salvaging a circuit board.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Circuit board to be repaired
- Soldering iron and stand
- Solder
- Replacement components
- Wire to create jumpers
- Drill and drill bits
- Isopropyl alcohol and clean cloth
- Solder sucker
- Solder wick
- Wire cutters
- Wire strippers
- Long-nose pliers
- Conformal coating solvent
- Adhesive

B. Procedure to replace a defective component

Note: A component can be replaced using the procedures described in Job Sheets 16 and 17 or the following method can be used, especially if a danger of lifting pads exists.

☐ 1. Turn on soldering iron and allow it to reach operating temperature.

Job Sheet 18

☐ 2. Identify component to be replaced.

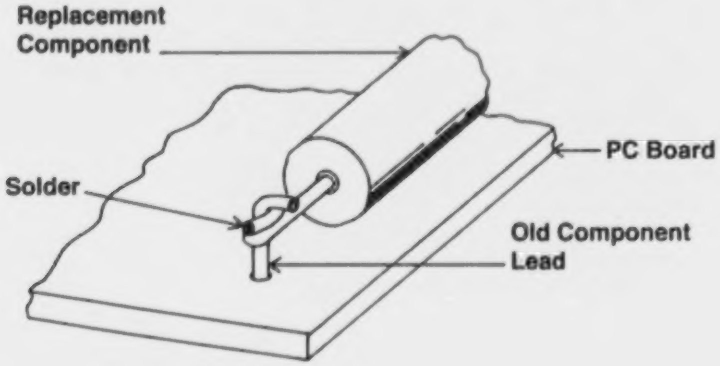
☐ 3. Clip component leads near body of component.

☐ 4. Position replacement component so that leads contact clipped leads of removed component, ensuring that component is correctly oriented for polarity or grounding.

☐ 5. Wrap leads of replacement component around clipped leads and cut off excess.

☐ 6. Solder leads where they join.

Figure 1



☐ 7. Turn off power to soldering iron.

☐ 8. Clean area that was soldered.

☐ 9. Return equipment and materials to their proper storage area.

C. Procedure to repair an open conductor path

☐ 1. Turn on soldering iron and allow it to heat up to operating temperature.

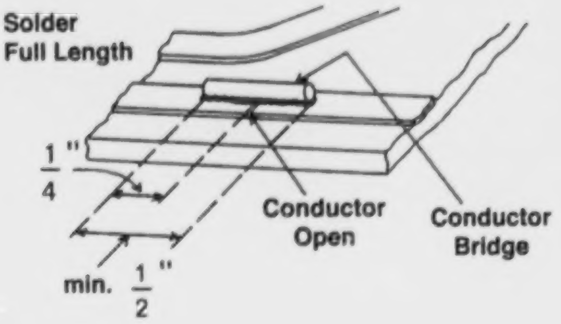
☐ 2. Identify conductor to be repaired and location of open if possible.

☐ 3. To repair the open using a bridge:

- Remove solder mask, conformal coating, and other materials from area where bridge is to be installed and then clean area with alcohol.
- Remove the insulation from a one-half inch section of solid wire and tin wire.
- Cut wire and position it evenly over the open.
- Solder the length of the bridge to the circuit board conductor with equal solder on each side of the open.

Job Sheet 18

Figure 2

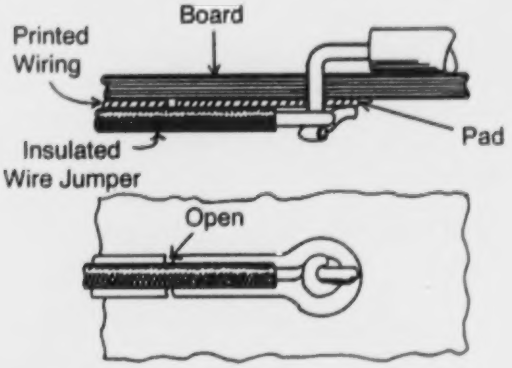

Solder
Full Length
1/4 "
min. 1/2 "
Conductor
Open
Conductor
Bridge

Solder Conductor Bridge Across Open as Shown

☐ 4. To repair the open using a jumper wire:

- Cut wire to length required to join components at each end of open conductor.
- Strip approximately one-half inch of insulation from each end of wire and tin leads.
- Solder ends of jumper wire to leads of components at each end of open conductor.

Figure 3


Board
Printed
Wiring
Pad
Insulated
Wire Jumper
Open

Solder Insulated Wire Jumper Across Open on Conductor Side of Board

☐ 5. Turn off power to soldering iron.

☐ 6. Clean area that was soldered.

☐ 7. Bond wire to board with adhesive along insulated portion of jumper.

☐ 8. Return equipment and materials to their proper storage area.

Job Sheet 18

D. Procedure to repair a lifted pad

☐ 1. Turn on soldering iron and allow it to heat up to operating temperature.

☐ 2. Identify the pad that is lifted.

☐ 3. Clip component lead to lifted pad where it meets the through-hole on the component side of the circuit board.

☐ 4. Desolder clipped lead and remove from through-hole; remove excess solder.

☐ 5. Repeat Step 4 for other leads until the component is free.

☐ 6. Determine length of jumper required to reach from component body, through damaged pad through-hole, and to circuit board conductor at least one-eighth inch beyond lifted area.

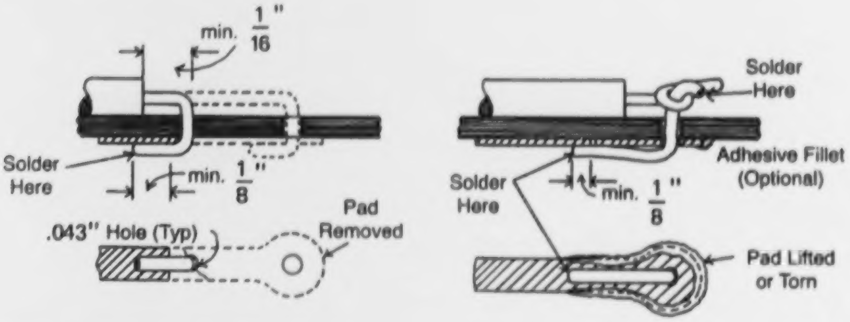
☐ 7. Strip and cut a jumper wire to the required length.

☐ 8. Tin jumper leads and insert jumper through through-hole.

☐ 9. Twist the component lead and the jumper wire together and solder.

☐ 10. Bend the other end of the jumper wire to contact the conductor at least one-eighth inch beyond the lifted pad and solder.

Figure 4


min. $\frac{1}{16}$"
Solder Here
min. $\frac{1}{8}$"
Pad Removed
.043" Hole (Typ)
Solder Here
Adhesive Fillet (Optional)
Solder Here
min. $\frac{1}{8}$"
Pad Lifted or Torn

☐ 11. Turn off power to soldering iron.

☐ 12. Clean area that was soldered.

Note: Adhesive can be applied to the edges of the lifted pad to seal it if desired.

☐ 13. Return equipment and materials to their proper storage area.

Job Sheet 18

E. Procedure to change circuit board circuits

☐ 1. Turn on soldering iron and allow it to heat up to operating temperature.

☐ 2. Identify circuit to be changed.

☐ 3. To remove circuit:

- Use a utility knife to cut completely across the conductor trace and clean with dry brush.
- Cover the cut area with conformal coating and allow to dry.

☐ 4. To install new circuit:

- Identify leads to be joined.
- Determine length of jumper wire required to reach between leads.
- Cut wire to required length and strip ends.
- Solder one end of wire to required lead and the other end to the other lead.

☐ 5. Turn off power to soldering iron.

☐ 6. Clean area that was soldered.

☐ 7. Return equipment and materials to their proper storage area.

Evaluator's comments:____

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Fabrication and Repair
Unit 3

Job Sheet 19—Inspect an Electronic Circuit and Identify Soldering and Fabrication Defects

Name ______________________ Attempt Number ______________

Date ______________________ Overall Rating ______________

Evaluation Criteria	**Rating**
• Equipment was set up correctly	________
• Correct procedures were followed	________
• Waveform presentation was clear and stable	________
• Frequency was correctly computed	________

Introduction: Most electronic manufacturing and repair facilities have a quality assurance program that is responsible for ensuring that the work done in the facility meets the applicable functional and workmanship standards. These goals are reached through systematic procedures that include extensive training programs and monitoring systems that involve inspection and testing of the facility's products. How well the facility does at meeting these goals is measured and recorded and displayed so that all workers know how well their organization is doing. A key to the success of such programs is that the workers know what is expected of them and are able to recognize defects in their own products and processes even if inspection is not a formal part of their duties.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Circuit board or other assembly to be inspected
- Inspection scope
- Drawings and other documents that define product and process standards
- Pencil and paper for recording defects

B. Procedure

☐ 1. Verify that each installed part is the correct part number.

☐ 2. Verify that each installed part is correctly oriented.

☐ 3. Verify that there are no part locations without installed parts.

☐ 4. Verify that the installed parts are marked as required.

Job Sheet 19

☐ 6. Verify that soldered joints are free of peaks, bridges, voids, and pinholes and that they provide sound electrical and mechanical connections.

☐ 7. Verify that soldered leads are properly clipped.

☐ 8. Verify that soldered wires are free of voids and bird-caging and that solder has not wicked up under the insulation.

☐ 9. Verify that mechanical fasteners are properly installed and torqued as required and that slots in the heads of threaded fasteners are not damaged.

☐ 10. Verify that rivets and swaged parts are properly seated and provide a secure installation.

☐ 11. Verify that connectors are properly installed and that exposed pins are free from damage.

☐ 12. Verify that ink marking, stamping, and labels are in place and provide the correct information.

☐ 13. Verify that wire routing is acceptable and does not present a risk of interference or damage.

☐ 14. Verify that conformal coating has been applied as required and provides an adequate seal.

☐ 15. Verify that assembly is clean and free from oil, fingerprints, solder and flux residue, and other contaminants.

☐ 16. Verify that assembly conforms to other applicable workmanship standards and requirements.

☐ 17. Perform required operational tests.

☐ 18. Record any defects that were found.

☐ 19. Return equipment and materials to their proper storage area.

Evaluator's comments: ______________________________

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DC and DC Circuits
Unit 4

Objective Sheet

Unit Objective

After completing this unit, the student should be able to discuss the use of direct current and the operation of DC circuits in electronic applications and be able to build and test DC circuits. The student should demonstrate these competencies by completing the assignment sheets and job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms associated with DC and DC circuits to their correct definitions.
2. State the reason for using direct current in electronic equipment.
3. Describe methods for providing direct current for electronic equipment.
4. Match common types of DC circuit components to their correct functions.
5. Match ways of classifying batteries to their correct descriptions.
6. Match lamps used in DC circuits to their correct descriptions.
7. Match lamps used in DC circuits to their correct symbols.
8. Match switches used in DC circuits to their correct descriptions.
9. Match switches used in DC circuits to their correct symbols.
10. Identify methods for manually actuating switches.
11. Identify circuit protection devices used in DC circuits.
12. Match circuit protection devices used in DC circuits to their correct descriptions.
13. Match circuit protection devices used in DC circuits to their correct symbols.
14. Identify types of resistors used in DC circuits.
15. Match resistors used in DC circuits to their correct descriptions.

Objective Sheet

16. Match resistors used in DC circuits to their correct symbols.
17. Label the meanings of color bands on a resistor.
18. Match colors used on resistors to their correct meanings.
19. Match inductors used in DC circuits to their correct descriptions.
20. Match inductors used in DC circuits to their correct symbols.
21. Explain the left-hand rule for conductors.
22. Explain the left-hand rule for coils.
23. Match sensor devices used in DC circuits to their correct descriptions.
24. Match sensor devices used in DC circuits to their correct symbols.
25. Match relays used in DC circuits to their correct descriptions.
26. Match relays used in DC circuits to their correct symbols.
27. Complete statements regarding the characteristics of voltage dividers.
28. Complete statements regarding the operation of loaded and unloaded voltage dividers.
29. Match types of bridge circuits to their correct symbols.
30. Identify types of bridge circuits by their schematics.
31. Calculate resistance values from color codes. (Assignment Sheet 1)
32. Determine total voltage in a series circuit. (Assignment Sheet 2)
33. Determine voltage drops across resistances. (Assignment Sheet 3)
34. Determine total resistance in a series circuit. (Assignment Sheet 4)
35. Determine current in a series circuit. (Assignment Sheet 5)
36. Compute power dissipated in a resistive series circuit. (Assignment Sheet 6)
37. Calculate current and voltage in parallel circuits. (Assignment Sheet 7)
38. Calculate resistance in parallel circuits. (Assignment Sheet 8)

Objective Sheet

39. Calculate power in parallel circuits. (Assignment Sheet 9)
40. Solve for branch voltages and currents in series-parallel circuits. (Assignment Sheet 10)
41. Solve for total resistance in series-parallel circuits. (Assignment Sheet 11)
42. Solve for total current in series-parallel circuits. (Assignment Sheet 12)
43. Solve for total voltage in series-parallel circuits. (Assignment Sheet 13)
44. Solve for total power in series-parallel circuits. (Assignment Sheet 14)
45. Analyze DC circuits. (Assignment Sheet 15)
46. Measure and compare current in a circuit at two different voltage levels. (Job Sheet 1)
47. Wire a functional relay circuit. (Job Sheet 2)
48. Measure the voltage drop in a DC circuit. (Job Sheet 3)
49. Construct a voltage divider and analyze its function. (Job Sheet 4)
50. Measure voltages in a balanced bridge circuit. (Job Sheet 5)
51. Measure voltages in an unbalanced bridge circuit. (Job Sheet 6)
52. Construct and operate a wheatstone bridge circuit. (Job Sheet 7)
53. Determine the maximum power transfer point on a resistor circuit. (Job Sheet 8)
54. Test and replace cells. (Job Sheet 9)
55. Test and replace lamps. (Job Sheet 10)
56. Test and replace switches. (Job Sheet 11)
57. Test and replace resistors. (Job Sheet 12)
58. Test and replace fuses and circuit breakers. (Job Sheet 13)
59. Test and replace capacitors. (Job Sheet 14)
60. Test and replace coils. (Job Sheet 15)

Objective Sheet

61. Test and replace sensor devices. (Job Sheet 16)
62. Test and replace relays. (Job Sheet 17)
63. Test and replace solenoids. (Job Sheet 18)
64. Troubleshoot DC circuits. (Job Sheet 19)

DC and DC Circuits
Unit 4

Information Sheet

1. **Terms and definitions**

   a. **Ballast**—Coil that opposes AC while allowing free flow of DC that is wired in series with one of the electrodes of a gas discharge lamp

   b. **Bias**—A level set as an operating point for an electrical or signal parameter such as voltage or resistance

   c. **Bleed current**—In a loaded voltage divider, that portion of the current that is routed through the voltage divider rather than the load

   d. **Bridge**—A component or device that is connected across the terminals of a bridge circuit

   e. **Color code**—Use of colors to represent characteristics of components

   f. **Electrolyte**—Substance that ionizes in solution used in batteries to produce electricity through chemical action

   g. **Fixed**—Of an electronic component, having a single value

   h. **Latching**—Referring to the characteristic of a component to lock into a value

   i. **Overcurrent**—A current that is higher than the specified current for a circuit

   j. **Overheat**—Condition of an electrical circuit or portion of a circuit in which the temperature rises above the designed operating temperature

   k. **Polarized**—Having or requiring a specific alignment of negative and positive leads or terminals

   l. **Reliability**—Expected performance life of a component or device under intended operational conditions

   m. **Tap**—Connection made to an intermediate point of a component, such as a coil or resistor

   n. **Tolerance**—Amount of variance that is allowed from a standard value for a product or process to still be considered acceptable

   o. **Variable**—Capable of changing in value or a characteristic that changes in value

2. **Reason for using direct current in electronic equipment**—Because electronic equipment deals with signals, direct current is used because changes in the current indicate changes in the signal.

Information Sheet

3. **Methods for providing direct current for electronic equipment**

   a. DC source—Use of a circuit power source that produces direct current

   b. Rectification—Routing AC through a device that allows electrical flow in one direction only

   Note: Electronic equipment that is powered by AC uses *rectifiers* to convert the AC to DC.

4. **Functions of common DC circuit components**

   a. Cells—Serve as power source

   b. Lamps—Provide illumination and serve as indicators

   c. Switches—Open and close circuits or redirect signals

   d. Resistors—Provide a desired level of opposition to electrical flow in a circuit

   e. Fuses—Protect circuits from overheating and overcurrent without reset capability

   f. Circuit breakers—Protect circuits from overheating or overcurrent with reset capability

   g. Capacitors—Collect excess electrons

   h. Coils—Produce inductance

   i. Thermistors—Provide variable level of resistance based on changes in temperature

   j. Relays—Provide switching capability in response to signals

   k. Solenoids—Produce mechanical movement through the use of electromagnetism

5. **Ways of classifying batteries**

   a. Packaging designations—Standardized codes usually consisting of one or more letters that represent the size, shape, and voltage of a battery or cell

   Examples: C, AA, AAA

   b. Voltage capacity—Fully charged output capability of the battery or cell

   c. Form of electrolyte—Classification generally based on whether the internal chemical used to produce electrical flow is a solid or liquid

   Examples: Dry cell, wet cell

Information Sheet

d. Type of electrolyte—Classification based on the battery chemical or chemical group

Examples: Acid, alkaline, potassium hydroxide, ammonium chloride

e. Type of electrodes—Classification based on the metal or dissimilar metals used to supply electrons for electrical flow

Examples: Lead, copper-zinc, nickel-cadmium, lithium, mercury-zinc

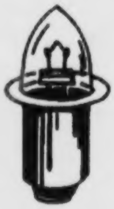
f. Capacity for recharging—Classification based on whether the cell or battery can be returned to a state of full voltage capacity or can only be used once until the charge is depleted

Examples: Primary vs. secondary (storage) batteries, rechargeable vs. nonrechargeable designs

6. Descriptions of lamps used in DC circuits

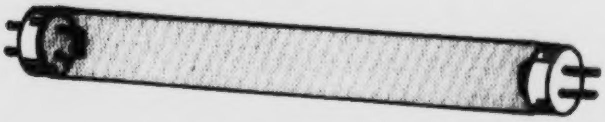
a. Incandescent—Lamp in which an internal conductor wire called a filament is heated so that it produces visible light

Example:



b. Fluorescent—Mercury-vapor glow lamp whose tube is lined with a phosphor that emits light when excited by the ultraviolet discharge created when an electrical current is sent through it

Example:



c. Glow lamp—Any of various types of lamps that use gas-filled tubes in which light is produced by the ionization of gas between the electrodes of the lamp

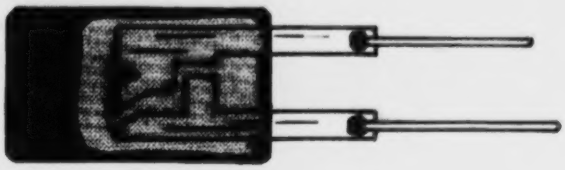
d. Ballast lamp—A glow lamp that uses an iron core choke circuit wired in series with one electrode to create an electrical discharge

e. Indicator lamp—A lamp that is coded—such as by its color, location, or marking—so that it provides information by being illuminated or not illuminated

Information Sheet

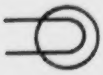
f. Light-emitting diode (LED)—A semiconductor device that gives off visible light when voltage is applied to its terminals

Example:

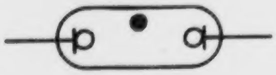


7. **Symbols for lamps used in DC circuits**

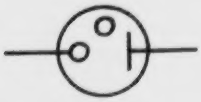
a. Incandescent



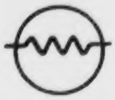
b. Fluorescent



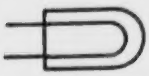
c. Glow lamp (direct current type)



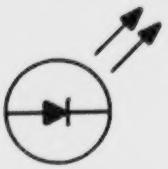
d. Ballast lamp



e. Indicator lamp



f. Light-emitting diode (LED)



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8. **Descriptions of switches used in DC circuits**

   a. Single-throw—A switch with one or more poles that move together between one position and a second position

   b. Double-throw—A switch with two or more poles that move together among three points so that one pole or set of poles is closed in one position, the other pole or set of poles is closed in a second position, and a third position exists where neither pole or set of poles is closed

   c. Pushbutton—A switch that is opened or closed by depressing it

   Note: Many pushbuttons are spring-loaded so that they return to a set position when released. Others lock in position once depressed and must be released by pressing them again or must be pulled out (push-pull knobs).

   d. Key-type—Term applied to two types of switches, one of which is operated by inserting and rotating a key and the other of which provides a momentary contact that automatically releases, such as a computer keyboard key or telegraph key

   e. Rotary—Switch with two or more positions that is actuated by turning it in a circular motion

   f. Slide—Switch with two or more positions that is actuated by moving it back and forth along a line

   g. Safety interlock—Switch wired in series with the power circuit of a piece of equipment so that certain conditions, such as opening a cabinet door or exceeding a safe operating speed, causes the switch to open and power to be removed

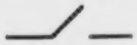
   h. Toggle—Switch whose on and off positions are at the extremes of the movement of a lever

   i. Thermostat—Switch that opens or closes as a result of changes in temperature, often through the use of a bi-metal conductor that bends to make or break contact as it expands and contracts in response to temperature changes

   j. Mercury switch—Switch that generally consists of two or more electrodes encased in a hollow, sealed body which contains a small quantity of mercury that is free to move so that changes in switch position make or break contact between the conductive mercury and a set of electrodes

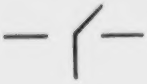
9. **Symbols for switches used in DC circuits**

   a. Single-throw

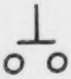


Information Sheet

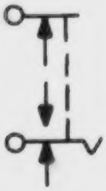
b. Double-throw



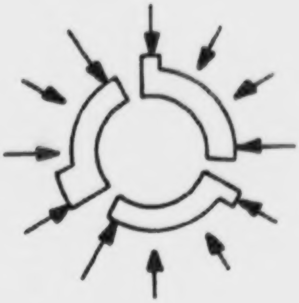
c. Pushbutton



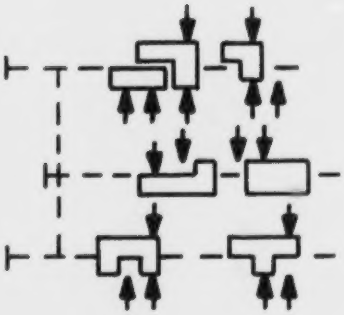
d. Key-type



e. Rotary



f. Slide



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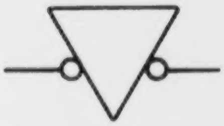
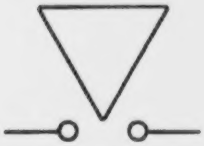
g. Safety interlock

- Circuit opening



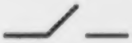
- Circuit closing



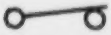
h. Toggle

Note: There is not a specific symbol for toggle switches. However, the symbols below for locking and nonlocking switches are commonly used to represent toggle switches.

- Nonlocking

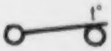


- Locking

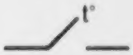


i. Thermostat

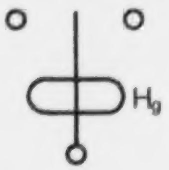
- Opens on rising temperature



- Opens on falling temperature

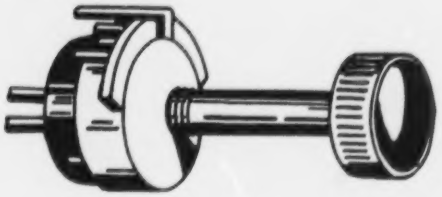


j. Mercury switch (three-terminal leveling shown)

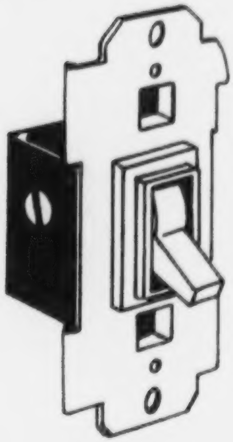


10. Methods for manually actuating switches

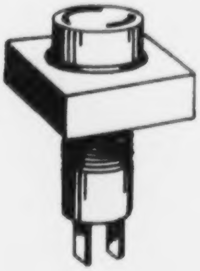
a. Knob



b. Lever



c. Pushbutton (or push-pull button)



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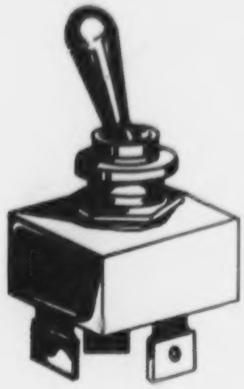
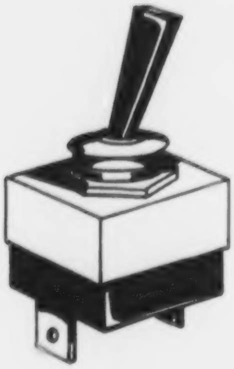
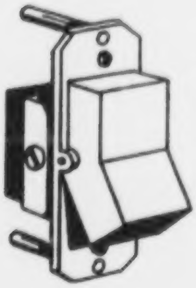
d. Bat handle



e. Paddle handle



f. Rocker



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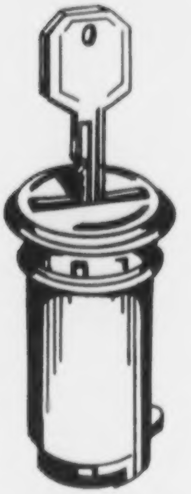
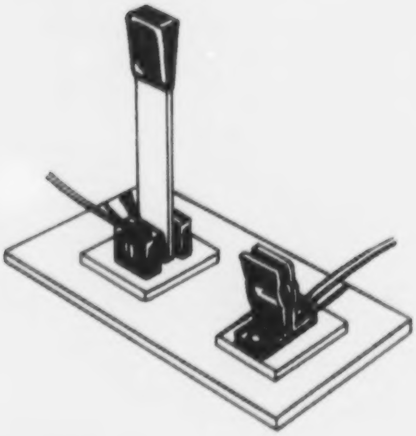
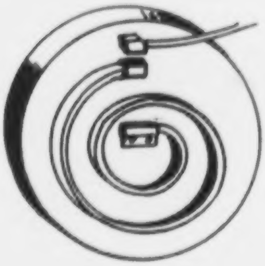
g. Key



h. Knife



i. Thermostat



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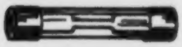
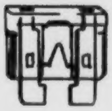
11. Types of circuit protection devices used in DC circuits

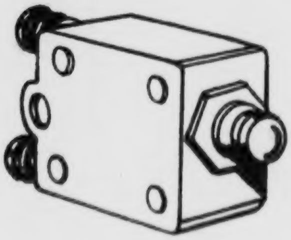
a. Cartridge fuse



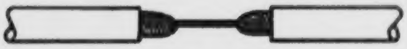
b. Blade fuse



c. Circuit breaker



d. Fusible link



12. Descriptions of circuit protection devices used in DC circuits

a. Fuse—Unresettable device with an internal conductor that is designed to melt in the event of a high current condition

b. Circuit breaker—Resettable device with moveable contacts that separate in the event of a high current condition

c. Fusible link—Segment of conductor spliced into a second conductor having a higher gauge than the second conductor so that it will melt more quickly than the larger conductor in the event of a high current condition

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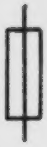
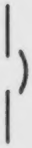
13. Symbols for circuit protection devices used in DC circuits

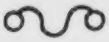
a. Fuse



b. Circuit breaker



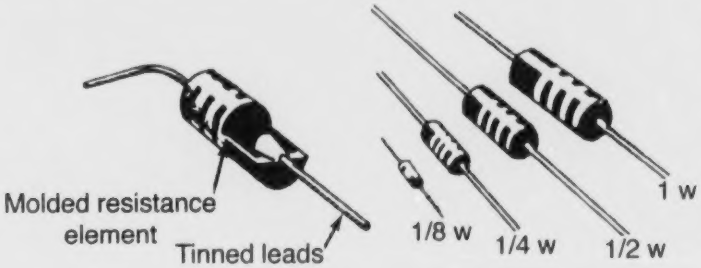
c. Fusible link



14. Types of resistors used in DC circuits

a. Fixed

- Carbon composition resistor


Molded resistance element
Tinned leads
1/8 w
1/4 w
1/2 w
1 w

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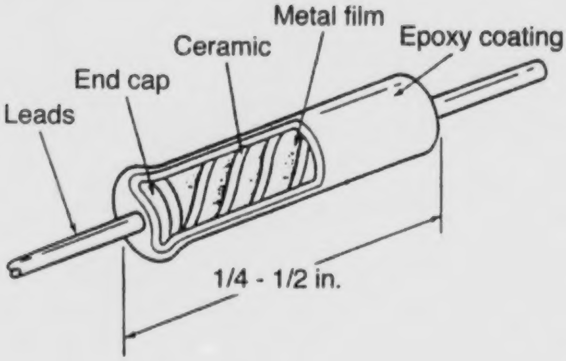
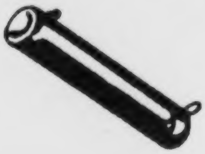
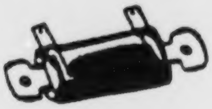
- Carbon film resistor


Metal film
Epoxy coating
Ceramic
End cap
Leads
1/4 - 1/2 in.

- Wire-wound resistor

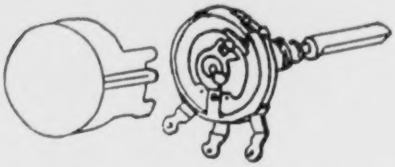


- Film element resistor

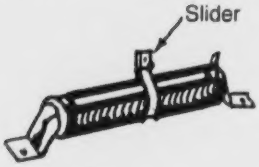


b. Variable

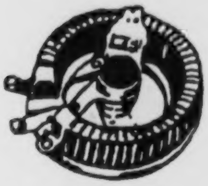
- Carbon composition potentiometer



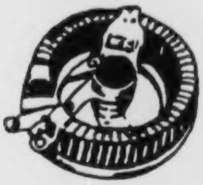
- Wire-wound variable resistor



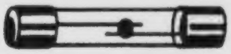
- Wire-wound potentiometer



- Wire-wound rheostat



- Thermistor



15. Descriptions of resistors used in DC circuits

a. Fixed

- Carbon composition resistor—Generally tube-shaped component consisting of a conductor enclosed in a mixture of carbon granules and insulating material in a binding agent and coated with a non-conductive substance
- Carbon film resistor—Component consisting of a conducting leads extending from a glass or ceramic rod that has been coated with thin layers of a resistive material and enclosed in a protective outer layer
- Wire-wound resistor—Component consisting of a ceramic tube wrapped in a coil of nickel-chromium alloy wire and covered with a protective coating
- Film element resistor—Component that opposes electrical flow through the use of a resistive substrate coated with a thin layer of resistive material such as tin oxide

b. Variable

- Carbon composition potentiometer—A three-terminal component constructed of circular carbon composition ribbons or wires with an arm attached to a moveable shaft so that the resistance varies as the shaft is turned

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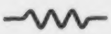
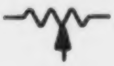
- Wire-wound variable resistor—Component consisting of a ceramic tube wrapped in a coil of nickel-chromium alloy wire with one terminal attached to a moveable slide that can be positioned along the coil to change the overall resistance of the component
- Wire-wound potentiometer—Three-terminal component consisting of a ceramic ring wrapped in nickel-chromium alloy wire with one terminal attached to a rotating shaft which moves the terminal connection around the ring to vary resistance
- Wire-wound rheostat—Two-terminal component consisting of a ceramic ring wrapped in nickel-chromium alloy wire with one terminal attached to a rotating shaft which moves the terminal connection around the ring to vary resistance
- Thermistor—A carbon-composition or film resistor that is constructed so that variations in temperature cause the overall resistance of the component to change

16. **Symbols for resistors used in DC circuits**

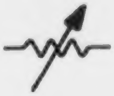
    a. Fixed

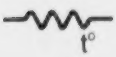
    b. Potentiometer

    c. Rheostat

    d. Thermistor

17. **Meanings of color bands on a resistor**

    a. First band—First significant number in resistance value

    b. Second band—Second significant number in resistance value

    c. Third band—Multiplier number for power of 10, which equates to the number of zeroes to add to the first and second significant numbers to get the resistance value

d. Fourth band—Shows tolerance as a percentage of the rated resistance

e. Fifth band—Reliability rating

18. Colors used on resistors

a. Black—Represents the number 0

b. Brown—Represents the number 1

c. Red—Represents the number 2 and the reliability rating 0.1

d. Orange—Represents the number 3 and the reliability rating 0.01

e. Yellow—Represents the number 4 and the reliability rating 0.001

f. Green—Represents the number 5

g. Blue—Represents the number 6

h. Violet—Represents the number 7

i. Gray—Represents the number 8

j. White—Represents the number 9

k. Gold—Represents the multiplier 0.1 and a 5-percent tolerance

l. Silver—Represents the multiplier 0.01 and a 10-percent tolerance

m. No color—Represents a 20-percent tolerance and indicates that reliability was not tested

19. Descriptions of inductors used in DC circuits

a. Coil (winding)—Any of various component configurations that include one or more conductors tightly wrapped around a body

b. Magnetic core—An inductor with a metal bar or ring (generally iron) within the winding to increase the induction strength

c. Tapped—An inductor that has a connection at an intermediate point of its winding

d. Adjustable—An inductor whose strength can be varied

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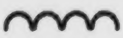
e. Relay coil—A switch that uses an electromagnetic actuator that responds to current applied to the winding or to increases in the current strength

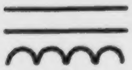
f. Solenoid—A general term for a coil and often applied specifically to one that has a magnetic core that is used as a mechanical actuator doe to its movement in response to electromagnetic induction

20. **Symbols for inductors used in DC circuits**

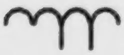
a. Coil (winding)



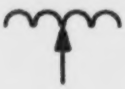
b. Magnetic core



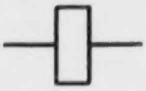
c. Tapped



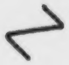
d. Adjustable



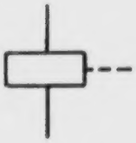
e. Relay coil



or



f. Solenoid



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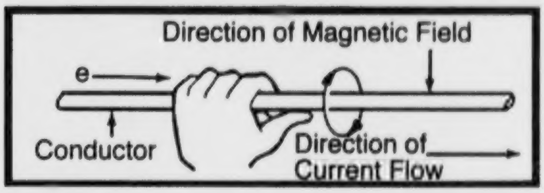
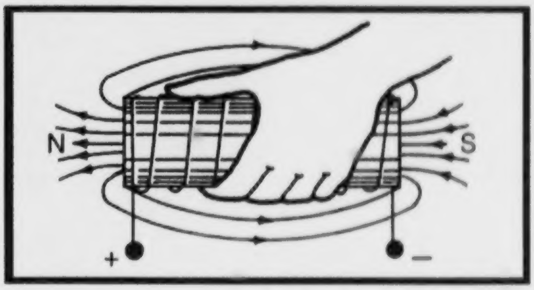
21. **The left-hand rule for conductors**—With your left hand grasping the conductor with your thumb pointing in the direction of electron flow, the direction of the induced magnetic field is in the direction your fingers point.



22. **The left-hand rule for coils**—With the coil isolated from power and your left-hand fingers wrapped around the coil in the direction of electron flow, your thumb points to the north pole of the coil.



23. **Descriptions of sensor devices used in DC circuits**

    a. Thermal sensors—Respond to changes in temperature

       Examples: Thermostats, thermistors

    b. Photo-sensitive devices—Respond to light levels

       Examples: Photoelectrical cell, optoelectronic coupler

    c. Pressure-sensitive devices—Respond to changes in pressure applied to the surface of the sensor

       Examples: Piezoelectric crystal, pressure switch

    d. Level sensors—Respond to changes in the level of a surrounding substance

       Examples: Float switch, fluid-level gauge

    e. Flow sensors—Respond to the rate of flow of a fluid

       Examples: Flow meter, flow relay

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f. Inertia sensors—Respond to changes in the amount of momentum of an object to which it is attached

Examples: Accelerometer, inertia switch

g. Ion sensors—Respond to the presence of specific substances in their immediate environment

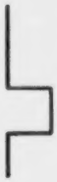
Examples: Geiger counter, smoke detector, leak detector

24. Symbols for sensor devices used in DC circuits

Note: Sensitive device symbols are often the basic device symbol with an added element such as a t° for temperature or the arrows used for showing photo-sensitivity. The symbols below represent the added element or show a specific device symbol as an example of how the sensor is illlustrated.

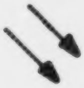
a. Thermal sensors

t° or



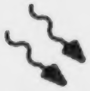
b. Photo-sensitive devices (two arrows pointing toward the component)

Note: The arrows may be used to indicate forms of nonionizing, electromagnetic waves besides light, such as radio waves.

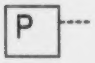


c. Ion sensors

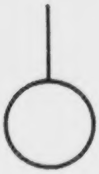
Note: Sensors that detect radiation, either ionizing or nonionizing, may be indicated by a meter in which the detector is just an internal component. Meters are generally indicated by a circle with letters inside it. The letters stand for the substance, energy, or condition that is detected or measured by the meter.



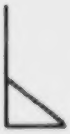
d. Pressure-sensitive devices (connected to device with dashed line)



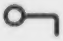
e. Level sensors



f. Flow sensors



g. Inertia sensors



25. Descriptions of relays used in DC circuits

a. Differential—Relay actuated by a difference between two currents or voltages

b. Double-biased—Relay that is actuated by changes in either of two parameters, such as polarity and voltage

c. Dashpot—Relay whose action is delayed by the movement of a piston

d. Electrically polarized—Relay that operates only in response to a specific polarity

e. Fast-operate—Relay that tends to make a circuit quickly

f. Fast-release—Relay that tends to break a circuit quickly

g. Latching—Relay that locks into whichever position (on or off) for which it is energized

h. Marginal—Relay with relatively small difference between its on and off power requirements

i. Magnetic latching—Relay with a permanent magnet in its coil that locks the relay into an energized position

j. No bias—Relay with no specific requirements for actuation, such as polarity or vast level differences in power for on and off

k. Nonreactive—A high-resistance relay

Information Sheet

l. Magnetically polarized—Relay which provides a specific magnetic polarity in response to induction

m. Slow-operate—Relay that is slow to make a circuit

n. Slow-release—Relay that is slow to break a circuit

26. Symbols for relays used in DC circuits

Note: In most cases, if a specific type of relay is required, the relay is shown with an abbreviation to indicate the particular type of relay. In a few cases, a symbol is used in place of letter abbreviations, as shown below.

a. Differential relay

D

b. Double-biased relay

DB

c. Dashpot

DP

d. Electrically polarized

EP

e. Fast-operate

FO

f. Fast-release

FR

g. Latching

L

h. Marginal

MG

i. Magnetic latching

ML

Information Sheet

j. No bias

NB

k. Nonreactive

NR

l. Magnetically polarized

+ or P

m. Slow-operate

X or SO

n. Slow-release

||||| or SR

27. **Characteristics of voltage dividers**

a. A voltage divider provides different voltage and current values for different loads from a single power source.

b. A voltage divider consists of two or more resistors connected in series across the power source.

c. The voltage is divided through successive voltage drops through the resistors.

d. If a chassis ground is used, the supplied voltage can be either negative or positive.

28. **Operation of loaded and unloaded voltage dividers**

a. Unloaded voltage dividers do not have loads attached.

b. Loaded voltage dividers have a load attached in parallel.

c. The divider generally is constructed to allow 90 percent of the total current to go through the load.

d. The current that does not flow through the load is called the *bleeder current* and flows through the series divider network.

Information Sheet

29. **Types of bridge circuits**

   a. Simple bridge—A series-parallel circuit which has two input terminals and two output terminals

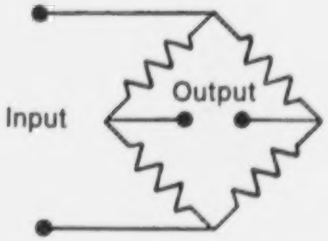
   b. Balanced bridge—Bridge design with proportional resistance in each branch so that the voltage output across the terminals is 0

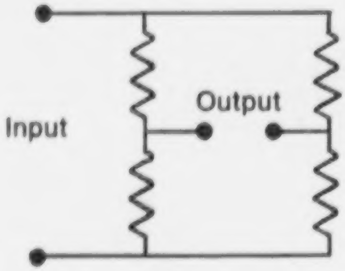
   c. Unbalanced bridge—Bridge design in which a potential difference exists across the output terminals

   d. Wheatstone bridge—Bridge design that includes a calibrated variable resistor in one branch so that a resistor of unknown value can be tested in the same branch by creating a balanced bridge

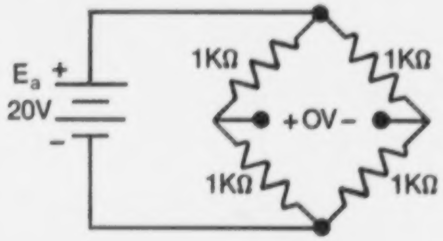
30. **Schematics of bridge circuits**

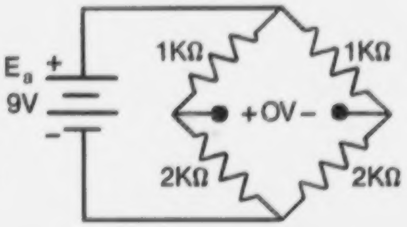
   a. Simple bridge





   b. Balanced bridge

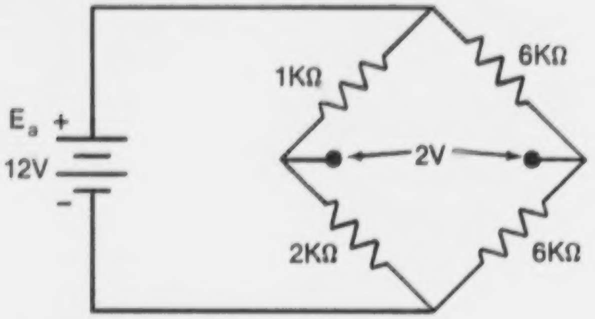




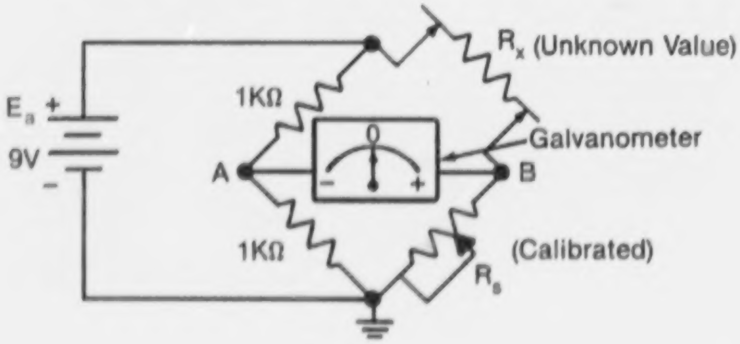
Note: In the schematic on the left, the resistors have the same value and the voltage across the output terminals is 0 volts. The circuit on the right has unequal resistors, and the voltage across the output terminals is also 0 volts because the voltage division within each branch is in equal proportion.

Information Sheet

c. Unbalanced bridge


1KΩ
6KΩ
E_a +
12V
−
2V
2KΩ
6KΩ

d. Wheatstone bridge


R_x (Unknown Value)
1KΩ
E_a +
9V
−
0
Galvanometer
A
−
+
B
1KΩ
(Calibrated)
R_s

DC and DC Circuits
Unit 4

Assignment Sheet 1— Calculate Resistance Values from Color Codes

Name ______________________________ Overall Rating __________

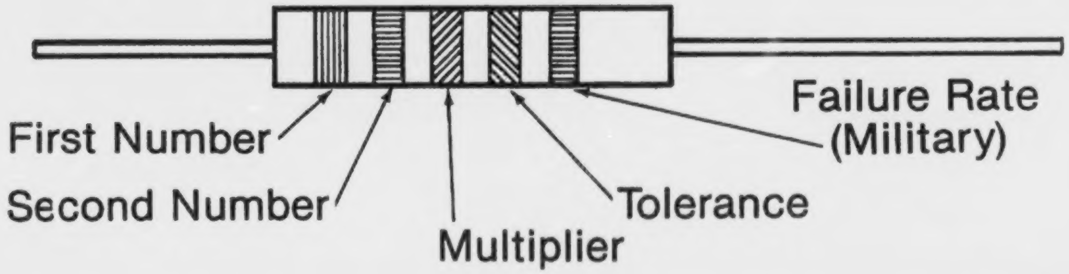
Evaluation criteria	**Rating**
• Directions have been followed	________
• Minimum of 82 percent of answers are correct	________
Note: Each correct answer is worth 6 points.	

Introduction: Component manufacturers used standardized color codes to mark resistors so that the value of the resistor and other information can be determined easily. Electronic technicians know how to interpret this color coding per the table below and frequently memorize the markings of resistors that they use often. This assignment sheet provides practice in how to read and interpret resistor color coding.

Directions: Study the next page and then use it to answer the questions on the following pages. Write your answers on the blanks provided for each question.

Assignment Sheet 1

Table 1: Resistor color code

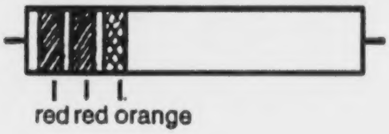

First Number
Second Number
Multiplier
Tolerance
Failure Rate (Military)

Color	First Number	Second Number	Multiplier	Tolerance	Failure Rate per 1000 hrs.
Black	0	0	1	± 20%	L 5%
Brown	1	1	10	± 1%	M 1%
Red	2	2	100	± 2%	P 0.1%
Orange	3	3	1000	----	R 0.01%
Yellow	4	4	10000	----	S 0.001%
Green	5	5	100000	----	T 0.0001%
Blue	6	6	1000000	----	
Violet	7	7	10000000	----	
Gray	8	8		----	
White	9	9		----	
Gold	----	----	0.1	± 5%	
Silver	----	----	0.01	± 10%	
No Color	----	----	----	± 20%	

Assignment Sheet 1

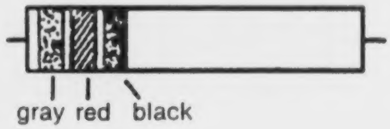
1. What is the resistance value of the resistor shown below?

____


red
red
orange

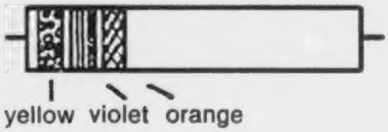
2. What is the resistance value of the resistor shown below?

____


gray
red
black

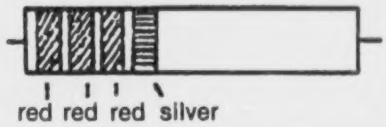
3. What is the resistance value of the resistor shown below?

____


yellow
violet
orange

4. What is the resistance value of the resistor shown below?

____


red
red
red
silver

5. What is the maximum resistance for the resistor in Question 4 if it is in tolerance?

____

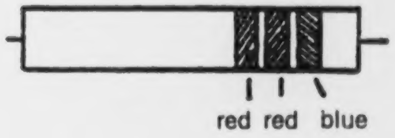
Assignment Sheet 1

6. What is the minimum resistance for the resistor in Question 4 if it is in tolerance?

____

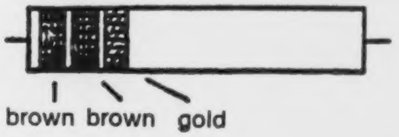
7. What is the resistance value of the resistor shown below?

____


red
red
blue

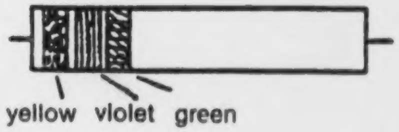
8. What is the resistance value of the resistor shown below?

____


brown
brown
gold

9. What is the resistance value of the resistor shown below?

____


yellow
violet
green

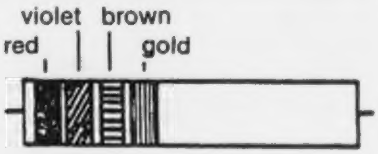
10. What is the greatest value that the resistor in Question 9 can have and still be in tolerance?

____

Assignment Sheet 1

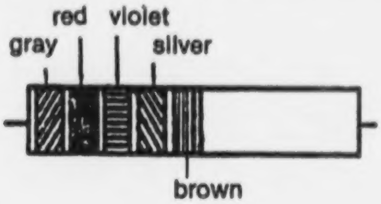
11. What is the resistance value of the resistor shown below?

____


violet
brown
red
gold

12. What is the resistance value of the resistor shown below?

____

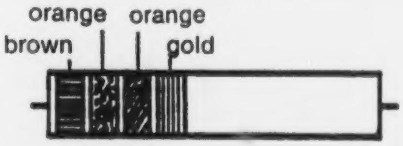

red
violet
gray
silver
brown

13. What is the meaning of the fifth color band in the resistor shown in Question 12?

____

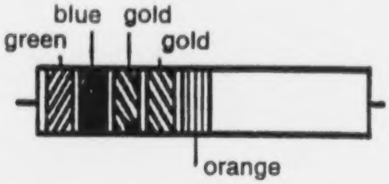
14. What is the resistance value of the resistor shown below?

____


orange
orange
brown
gold

15. What is the resistance value of the resistor shown below?

____


blue
gold
green
gold
orange

Assignment Sheet 1

16. Of the resistors shown in this assignment sheet, which would pass the greatest amount of current if the voltage were held constant? Write the number of the question in which that resistor is illustrated.

17. Of the resistors shown in this assignment sheet, which would pass the least amount of current if the voltage were held constant? Write the number of the question in which that resistor is illustrated.

DC and DC Circuits
Unit 4

Assignment Sheet 2— Determine Total Voltage in a Series Circuit

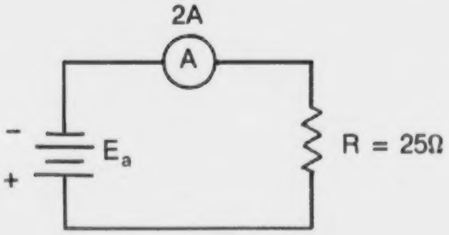
Name ____ Overall Rating__________

Evaluation criteria	Rating
• Directions have been followed	________
• Minimum of 87 percent of answers are correct	________
Note: Each correct answer is worth 12.5 points.	

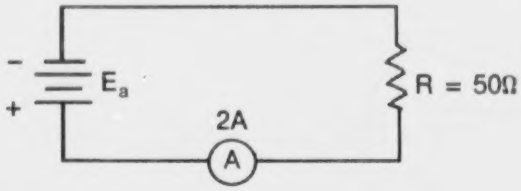
Introduction: One of the basic applications of Ohm's Law in a DC circuit is to determine the total voltage. The exercises below will help you practice this skill.

Directions: Study the schematics shown below and on the next page. Apply Ohm's Law to determine the total voltage in the circuit. Write your answers in the space provided with each schematic.

1. E_a = ______________

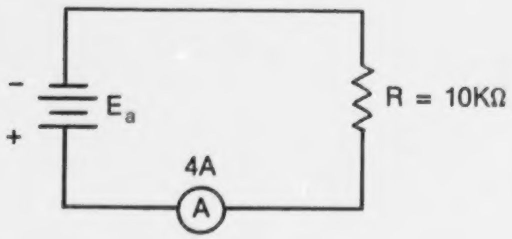


2. E_a = ______________

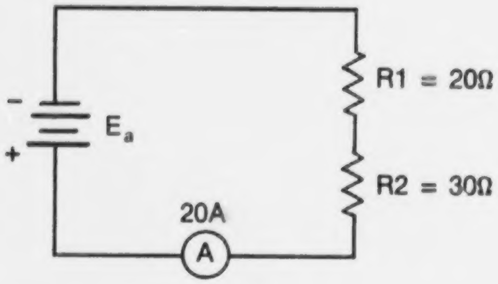


Assignment Sheet 2

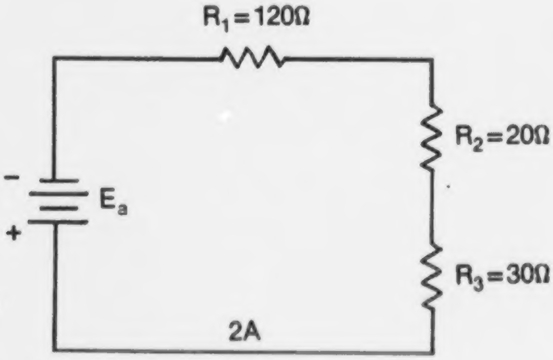
3. E_a = ______________


–
+
E_a
R = 10KΩ
4A
A

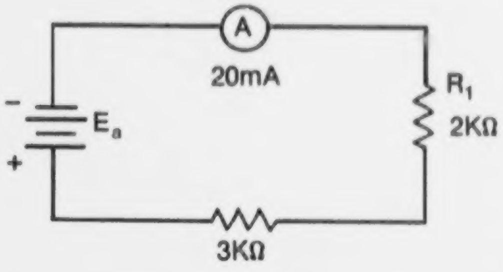
4. E_a = ______________


–
+
E_a
R1 = 20Ω
R2 = 30Ω
20A
A

5. E_a = ______________

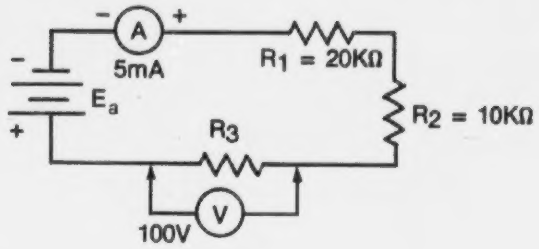

R_1 = 120Ω
R_2 = 20Ω
R_3 = 30Ω
–
+
E_a
2A

6. E_a = ______________

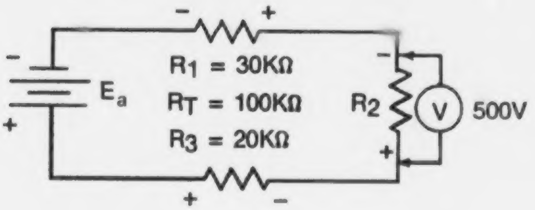

A
20mA
R_1
2KΩ
–
+
E_a
3KΩ

Assignment Sheet 2

7. E_a = _______________


A
5mA
R_1 = 20KΩ
E_a
R_2 = 10KΩ
R_3
V
100V

8. E_a = _______________


E_a
R_1 = 30KΩ
R_T = 100KΩ
R_3 = 20KΩ
R_2
V
500V

DC and DC Circuits
Unit 4

Assignment Sheet 3— Determine Voltage Drops Across Resistances

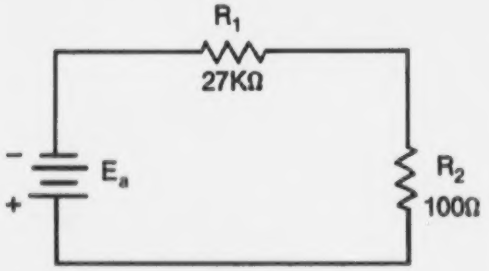
Name ______________________________ Overall Rating__________

Evaluation criteria	**Rating**
• Directions have been followed	______
• Minimum of 80 percent of answers are correct	______
Note: Each correct answer is worth 20 points.	

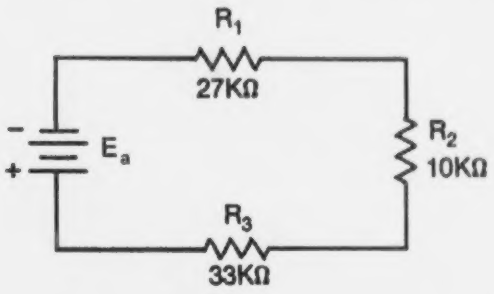
Introduction: In Job Sheet 3, you will measure voltage drops in a DC circuit. However, to prepare for that task, you should review Kirchhoff's voltage law to understand the principles at work in these circuits. This assignment sheet will provide you with practice in applying those principles.

Directions: Study the schematics below and on the next page and answer the questions accompanying each. Write your answers in the spaces provided with each question.

1. Which of the two resistors will produce the greater voltage drop?__________________

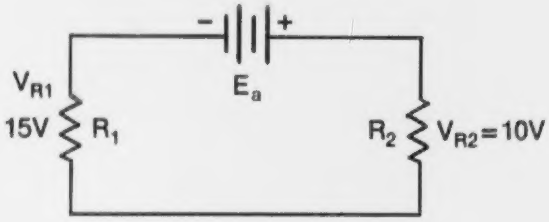


2. Which of the three resistors will produce the greatest voltage drop?________________

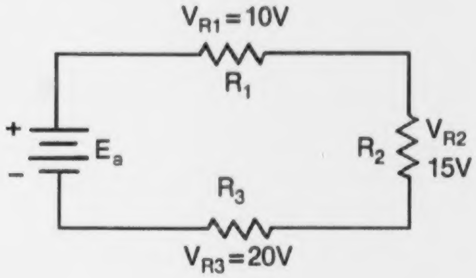


Assignment Sheet 3

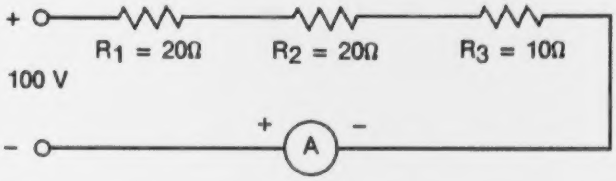
3. E_a = ______________


–
+
E_a
V_{R1}
15V
R_1
R_2
V_{R2}=10V

4. E_a = ______________


V_{R1}=10V
R_1
+
–
E_a
R_2
V_{R2}
15V
R_3
V_{R3}=20V

5. V_3 = ______________


+
100 V
–
R_1 = 20Ω
R_2 = 20Ω
R_3 = 10Ω
+
A
–

DC and DC Circuits
Unit 4

Assignment Sheet 4— Determine Total Resistance in a Series Circuit

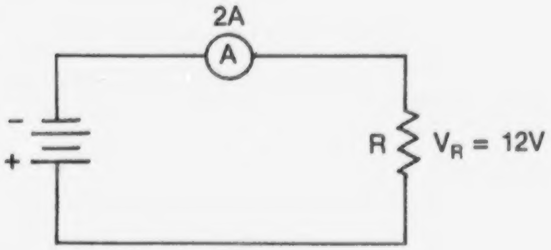
Name ______________________________ Overall Rating__________

Evaluation criteria	**Rating**
• Directions have been followed	________
• Minimum of 80 percent of answers are correct	________
Note: Each correct answer is worth 20 points.	

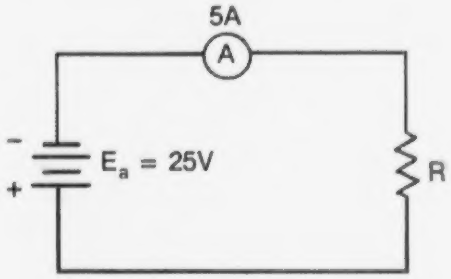
Introduction: As an electronics technician, you will need to be able to predict the expected values of the electrical characteristics of circuits. In this assignment sheet, you will practice determining the expected total resistance of a circuit.

Directions: Study the schematics below and on the next page and determine the total resistance in each circuit. Write your answers in the spaces provided with each drawing.

1. R_t = ____________

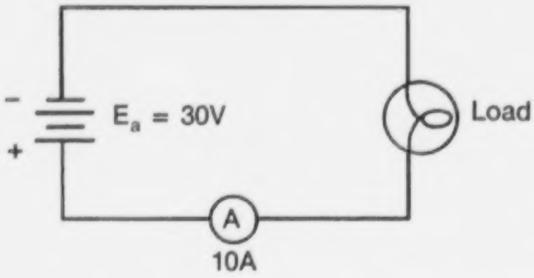


2. R_t = ____________

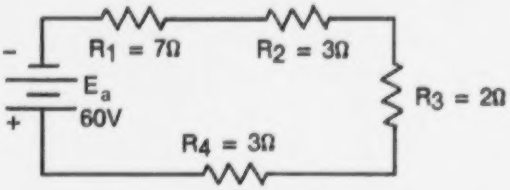


Assignment Sheet 4

3. R_t = ______________

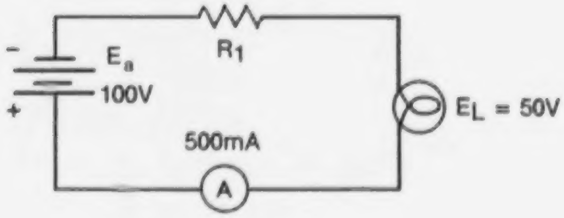

−
+
E_a = 30V
Load
A
10A

4. R_t = ______________


−
+
R_1 = 7Ω
R_2 = 3Ω
E_a
60V
R_3 = 2Ω
R_4 = 3Ω

5. In designing the circuit below, the technician wants the lamp to illuminate at 50 volts. What value of resistor should be used to achieve this?

R_t = ______________


−
+
E_a
100V
R_1
500mA
A
E_L = 50V

DC and DC Circuits
Unit 4

Assignment Sheet 5— Determine Current in a Series Circuit

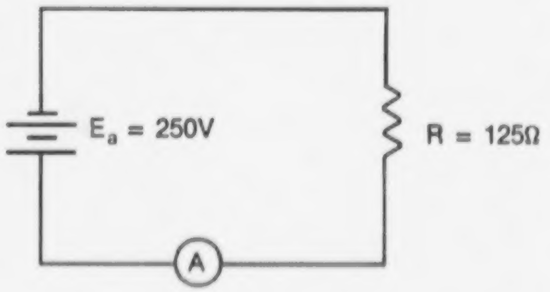
Name ______________________________ Overall Rating__________

Evaluation criteria	Rating
• Directions have been followed	________
• Minimum of 80 percent of answers are correct	________
Note: Each correct answer is worth 20 points.	

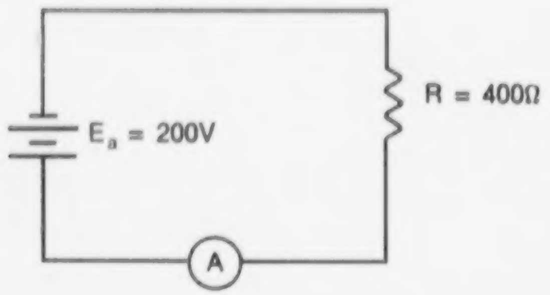
Introduction: Analyzing the performance of a circuit requires that you be able to predict the expected values of the electrical characteristics of circuits, including current. In this assignment sheet, you will practice determining the expected current of a circuit.

Directions: Study the schematics below and on the next page and determine the current in each circuit. Write your answers in the spaces provided with each drawing.

1. I = ____________

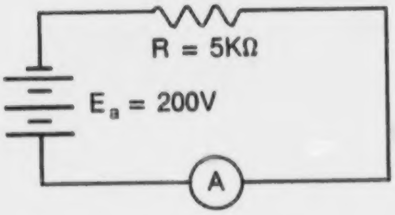


2. I = ____________

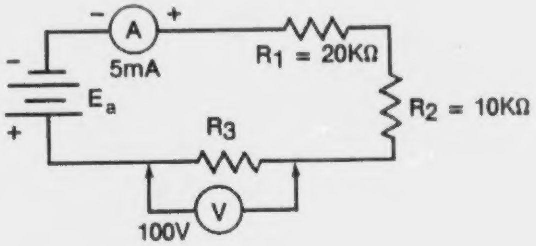


Assignment Sheet 5

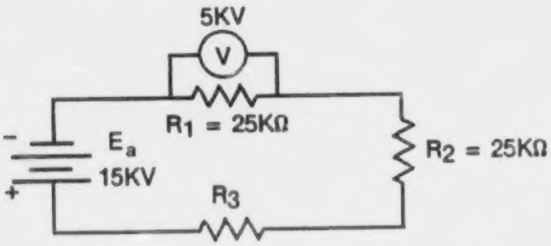
3. I = ______________ milliamperes


R = 5KΩ
E_a = 200V
A

4. I = ______________


−
A
+
5mA
R_1 = 20KΩ
−
E_a
+
R_2 = 10KΩ
R_3
V
100V

5. I = ______________


5KV
V
R_1 = 25KΩ
−
E_a
15KV
+
R_2 = 25KΩ
R_3

DC and DC Circuits
Unit 4

Assignment Sheet 6— Compute Power Dissipated in a Resistive Series Circuit

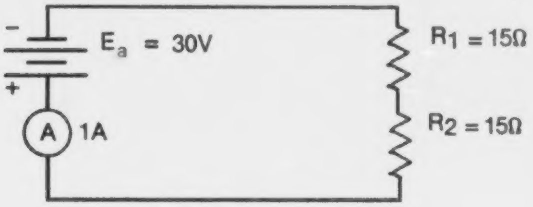
Name ______________________________ Overall Rating __________

Evaluation criteria	Rating
- Directions have been followed	______
- Minimum of 80 percent of answers are correct	______
Note: Each correct answer is worth 20 points.	

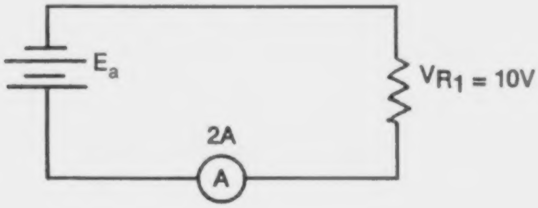
Introduction: Often the real concern in designing or analyzing a circuit is the need to determine the power requirements to accomplish the work that needs to be done. In many cases, this determination is one of deciding on the best balance between current and voltage and the resistances needed to achieve that balance. The problems below will help you to explore these relationships.

Directions: Study the schematics below and on the next page and determine the power dissipated in each circuit or portion of the circuit as requested. Write your answers in the spaces provided with each drawing.

1. P_t = __________

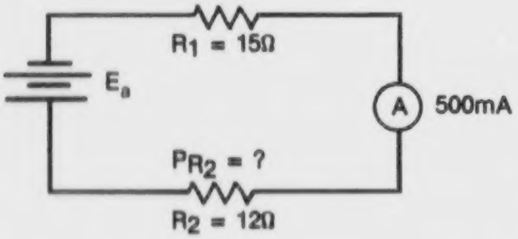


2. P_{R1} = __________

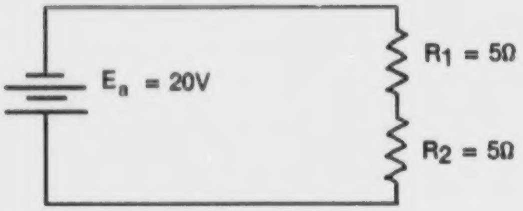


Assignment Sheet 6

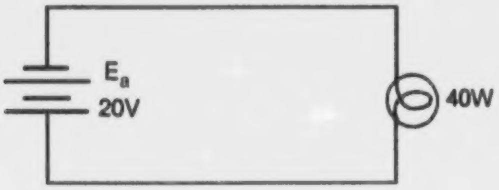
3. P_{R2} = ______________


R1 = 15Ω
Ea
A
500mA
PR2 = ?
R2 = 12Ω

4. P_t = ______________


Ea = 20V
R1 = 5Ω
R2 = 5Ω

5. If the lamp in the circuit below is using 40 watts, what is the current?_______________



DC and DC Circuits
Unit 4

Assignment Sheet 7— Calculate Current and Voltage in Parallel Circuits

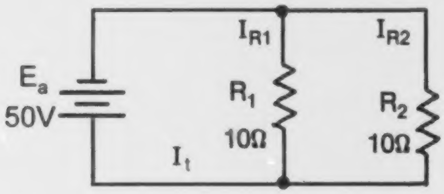
Name ____________________________ Overall Rating__________

Evaluation criteria	**Rating**
• Directions have been followed	________
• Minimum of 85 percent of answers are correct	________
Note: Each correct answer is worth 3 points.	

Introduction: DC circuits can use a parallel circuit design, requiring the technician to be able to determine electrical characteristics in these types of circuits. This assignment sheet includes problems to provide you with practice in this vital skill.

Directions: Study the schematics below and on the following pages. Then calculate the electrical characteristics listed with each drawing. Write your answers in the spaces provided with each drawing.

1.



a. E_{R1} = ________________

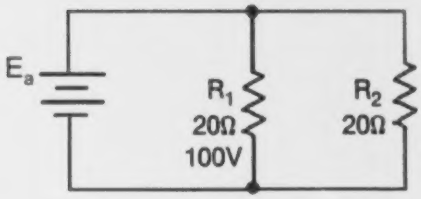
b. I_{R1} = ________________

c. E_{R2} = ________________

d. I_{R2} = ________________

e. I_T = ________________

2.



a. E_a = ________________

b. I_{R1} = ________________

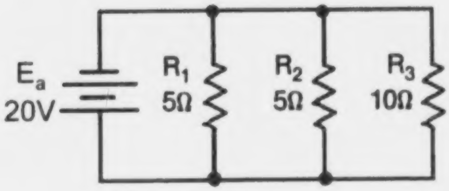
c. E_{R2} = ________________

d. I_{R2} = ________________

e. I_T = ________________

Assignment Sheet 7

3.


E_a
20V
R_1
5Ω
R_2
5Ω
R_3
10Ω

a. E_{R1} = ____________________

b. E_{R2} = ____________________

c. E_{R3} = ____________________

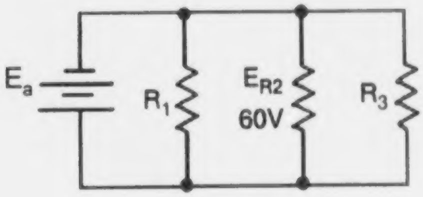
d. I_{R1} = ____________________

e. I_{R2} = ____________________

f. I_{R3} = ____________________

g. I_T = ____________________

4.

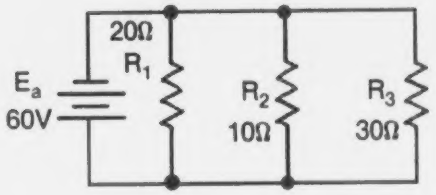

E_a
R_1
E_{R2}
60V
R_3

a. E_{R1} = ____________________

b. E_{R3} = ____________________

c. E_a = ____________________

5.


20Ω
R_1
E_a
60V
R_2
10Ω
R_3
30Ω

a. I_{R1} = ____________________

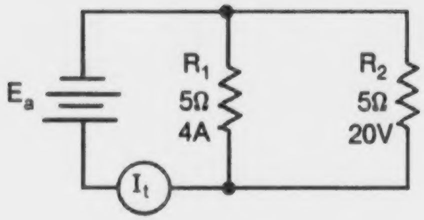
b. I_{R2} = ____________________

c. I_{R3} = ____________________

d. I_t = ____________________

Assignment Sheet 7

6.


E_a
R_1
5Ω
4A
R_2
5Ω
20V
I_t

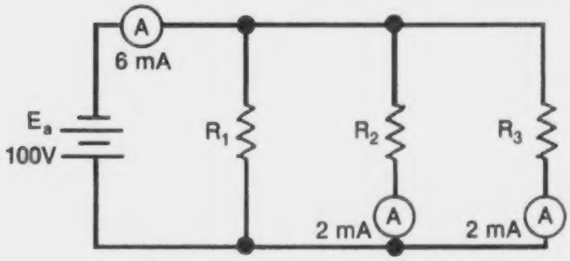
a. I_{R2} = ________

b. I_t = ________

c. E_{R1} = ________

d. E_a = ________

7.


A
6 mA
E_a
100V
R_1
R_2
R_3
2 mA
A
2 mA
A

a. I_t = ________

b. I_{R1} = ________

c. E_a = ________

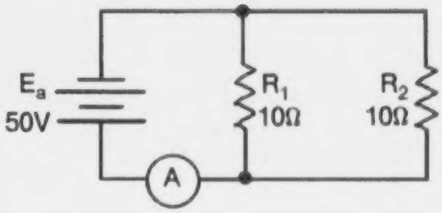
d. E_{R1} = ________

e. E_{R2} = ________

f. E_{R3} = ________

8. In the circuit below, what current value would the ammeter indicate?

____


E_a
50V
R_1
10Ω
R_2
10Ω
A

DC and DC Circuits
Unit 4

Assignment Sheet 8— Calculate Resistance in Parallel Circuits

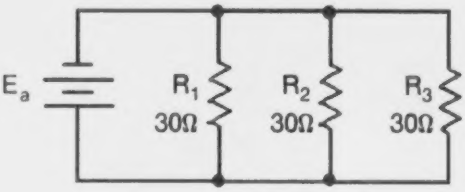
Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
• Directions have been followed	________
• Minimum of 87 percent of answers are correct	________
Note: Each correct answer is worth 12.5 points.	

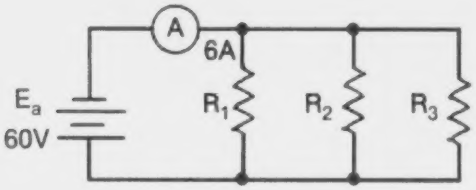
Introduction: Resistance values in parallel circuits behave a bit differently than those in series circuits, often requiring the electronics technician to convert the circuit to an equivalent series circuit in order to determine resistance values. Apply the principles that you have learned to determine the resistance values of circuits shown in this assignment sheet.

Directions: Study the schematics below and on the next page and determine the total resistance in each circuit. Write your answers in the spaces provided with each drawing.

1. R_t = ____________

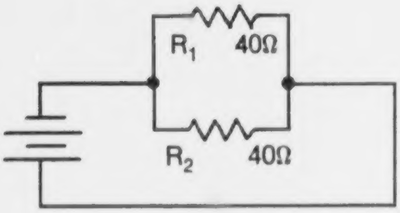


2. If all the resistors have the same value, R_t = ____________

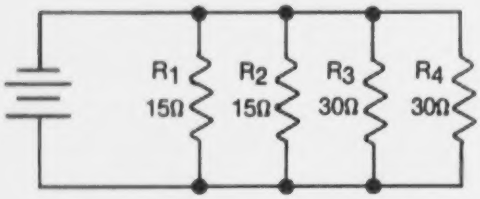


Assignment Sheet 8

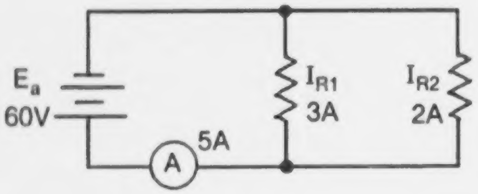
3. R_t = ______________


R1
40Ω
R2
40Ω

4. R_t = ______________


R1
15Ω
R2
15Ω
R3
30Ω
R4
30Ω

5.


E_a
60V
A
5A
I_{R1}
3A
I_{R2}
2A

a. R_1 = ______________

b. R_2 = ______________

c. R_t = ______________

d. $\frac{E_t}{I_t}$ = ______________

DC and DC Circuits
Unit 4

Assignment Sheet 9— Calculate Power in Parallel Circuits

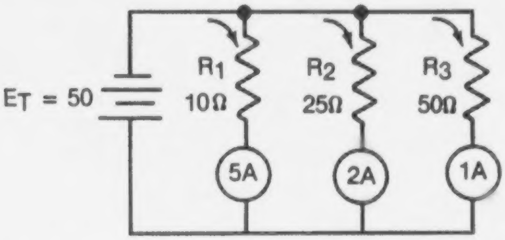
Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
• Directions have been followed	________
• Minimum of 80 percent of answers are correct	________
Note: Each correct answer is worth 20 points.	

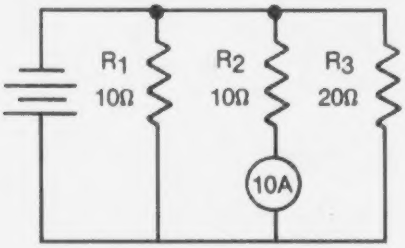
Introduction: Power dissipation in parallel circuits follows Watt's Law as it does in other circuits. The technician must be careful to correctly determine the voltage and current values or other unknowns so that Watt's Law can be applied. The following problems will allow you to practice determining power in parallel circuits.

Directions: Study the schematics below and on the next page and determine the power dissipated in each circuit or portion of the circuit as requested. Write your answers in the spaces provided with each drawing.

1. P_t = __________

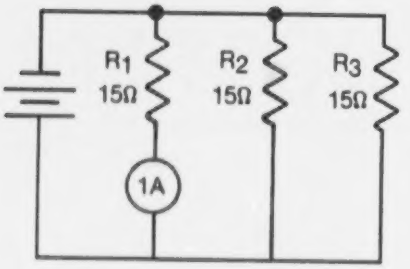


2. P_t = __________

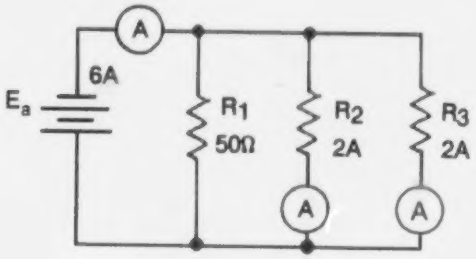


Assignment Sheet 9

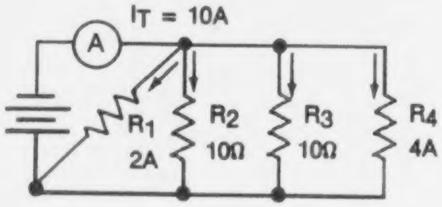
3. P_t = ____________


R1
15Ω
R2
15Ω
R3
15Ω
1A

4. P_t = ____________


A
6A
Ea
R1
50Ω
R2
2A
R3
2A
A
A

5. P_t = ____________


IT = 10A
A
R1
2A
R2
10Ω
R3
10Ω
R4
4A

DC and DC Circuits
Unit 4

Assignment Sheet 10— Solve for Branch Voltages and Currents in Series-Parallel Circuits

Name ______________________________ Overall Rating__________

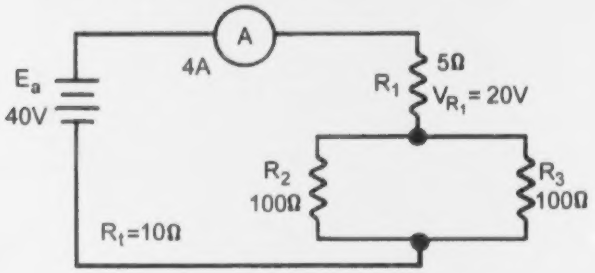
Evaluation criteria	Rating
• Directions have been followed	________
• Minimum of 80 percent of answers are correct	________

Note: Each correct answer is worth 10 points.

Introduction: As you continue your career in electronics, you will encounter increasingly complex circuits. It will often be difficult to distinguish subcircuits and to determine what configurations are represented in terms of series and parallel circuits. By developing a sound understanding of circuit operation in series-parallel circuits, you will build a firm foundation that will help you understand the more difficult circuits with which you will work. This assignment sheet will help you establish such a foundation.

Directions: Study the drawings below and on the following pages. Determine the values requested. Write your answers in the spaces provided with each drawing.

1.



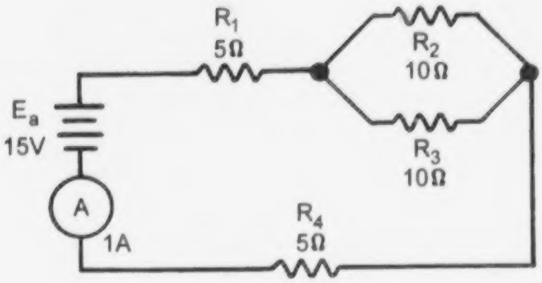
a. V_{R3} = __________

b. I_{R2} = __________

c. V_{R2} = __________

Assignment Sheet 10

2.


R$_1$
5Ω
R$_2$
10Ω
R$_3$
10Ω
E$_a$
15V
A
1A
R$_4$
5Ω

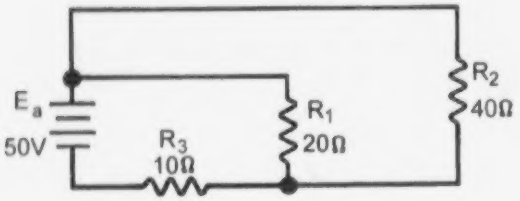
a. V_{R4} = __________

b. V_{R2} = __________

c. I_{R3} = __________

d. V_{R1} = __________

3.


E$_a$
50V
R$_3$
10Ω
R$_1$
20Ω
R$_2$
40Ω

a. V_{R2} = __________

b. I_{R1} = __________

c. I_{R2} = __________

DC and DC Circuits
Unit 4

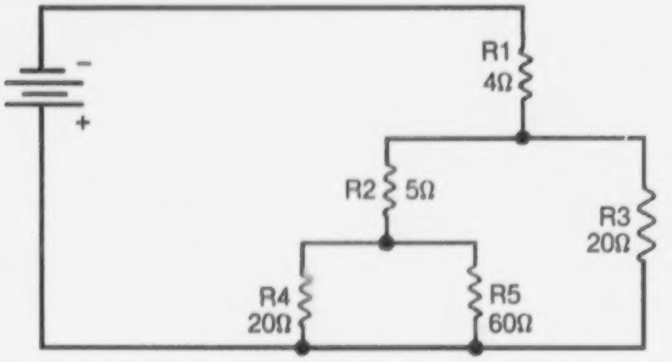
Assignment Sheet 11— Solve for Total Resistance in Series-Parallel Circuits

Name ______________________________ Overall Rating__________

Evaluation criteria	**Rating**
• Directions have been followed	________
• Minimum of 80 percent of answers are correct	________

Note: Each correct answer is worth 20 points.

Introduction: One of the complexities that the electronics technician will find in series-parallel circuits is the parallel circuit that branches into another parallel circuit. Determining total resistance in such a circuit requires the technician to examine the circuit, reduce it to equivalent series circuits (often more than once), and computing resistance based on the reduced circuit. This assignment sheet will guide you through that process using the circuit illustrated below.



Directions: Study the schematic drawing above. Then complete the steps listed below to determine total resistance. Show your work for each step in the space provided and write your answers on the blanks beside each question.

Assignment Sheet 11

1. First, find R_{eq} for R_4 and R_5.

   R_{eq} = ____________

2. In the space below, redraw the circuit with the R_{eq} for R_4 and R_5. Label the values of the components in the new circuit.

3. The equivalent circuit with R_4 and R_5 combined can be further reduced because the equivalent circuit and R_2 are not in series and are additive. Combine R_2 and R_{eq} into a second equivalent circuit. Redraw the circuit with the new branch labeled as R_{eq2}.

Assignment Sheet 11

4. In your revised circuit, R_{eq2} should now be in parallel with R_3. Therefore, the circuit needs to be further reduced. Place Req_2 and R_3 in series to produce R_{eq3}. Redraw the circuit in the space below and label the components with the proper values.

5. Redraw the circuit in its final reduced state showing one equivalent resistor, R_t.

DC and DC Circuits
Unit 4

Assignment Sheet 12— Solve for Total Current in Series-Parallel Circuits

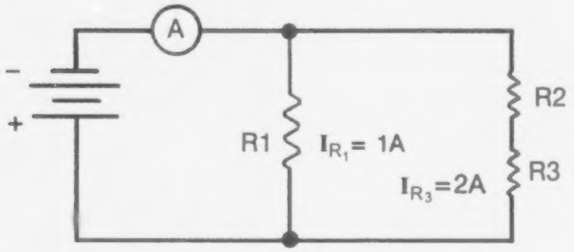
Name ______________________________ Overall Rating__________

Evaluation criteria	**Rating**
• Directions have been followed	________
• Minimum of 80 percent of answers are correct	________
Note: Each correct answer is worth 20 points.	

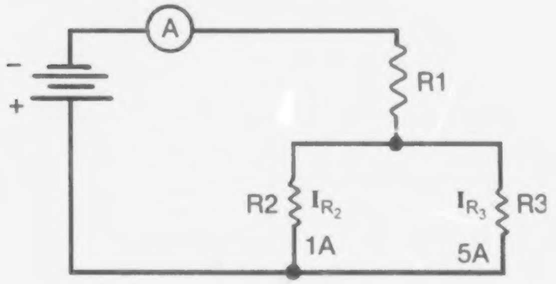
Introduction: In the previous assignment sheet, you practiced reducing series-parallel circuits to determine equivalent resistance. In this assignment sheet, you will apply Ohm's Law and other principles that you have learned to determine current values in a circuit.

Directions: Study the schematics below and on the next page and determine the current in each circuit. Write your answers in the spaces provided with each drawing.

1. I = __________

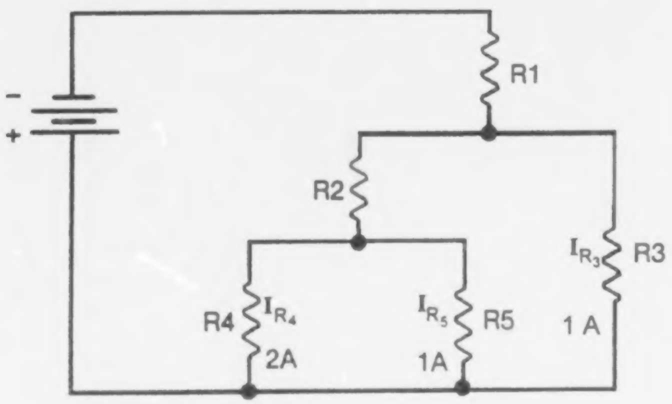


2. I = __________

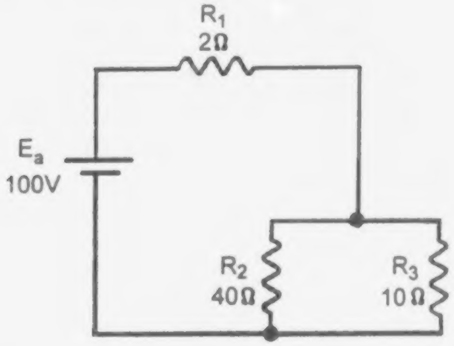


Assignment Sheet 12

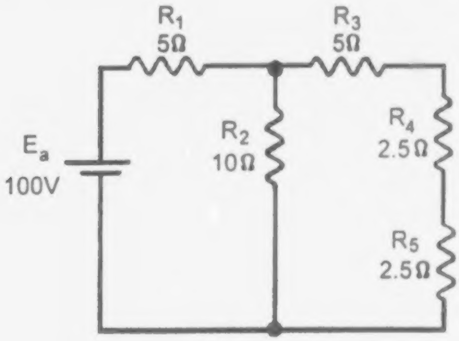
3. I = ____________


−
+
R1
R2
I_{R_3}
R3
R4
I_{R_4}
2A
I_{R_5}
R5
1A
1 A

4. I = ____________


R_1
2Ω
E_a
100V
R_2
40Ω
R_3
10Ω

5. I = ____________


R_1
5Ω
R_3
5Ω
E_a
100V
R_2
10Ω
R_4
2.5Ω
R_5
2.5Ω

DC and DC Circuits
Unit 4

Assignment Sheet 13— Solve for Total Voltage in Series-Parallel Circuits

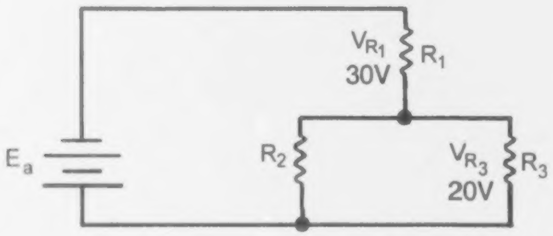
Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
• Directions have been followed	________
• Minimum of 80 percent of answers are correct	________
Note: Each correct answer is worth 20 points.	

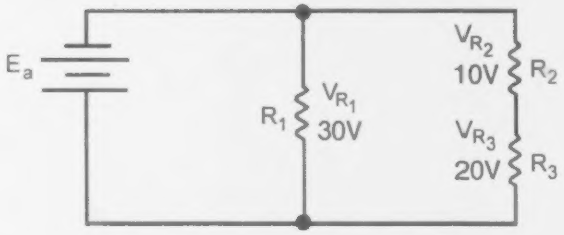
Introduction: One of the basic applications of Ohm's Law in a DC circuit is to determine the total voltage. As circuits become more complex—such as the series-parallel circuits in this assignment sheet—that application becomes more involved. The exercises below will help you practice this skill.

Directions: Study the schematics shown below and on the next page. Apply Ohm's Law to determine the total voltage in the circuit. Write your answers in the space provided with each schematic.

1. E_a = __________

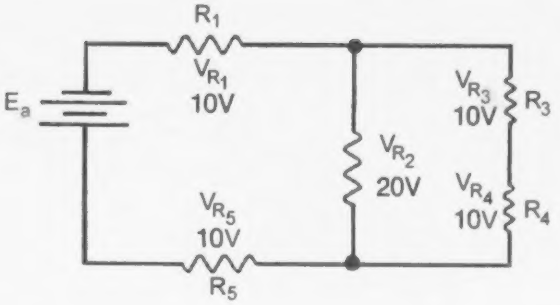


2. E_a = __________

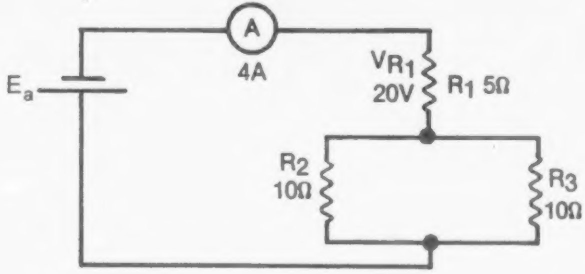


Assignment Sheet 13

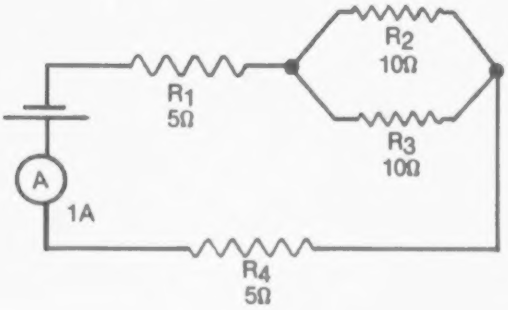
3. E_a = ____________


R1
V_{R_1}
10V
E_a
V_{R_2}
20V
V_{R_3}
10V
R3
V_{R_4}
10V
R4
V_{R_5}
10V
R5

4. E_a = ____________


A
4A
E_a
V_{R_1}
20V
R1 5Ω
R2
10Ω
R3
10Ω

5. E_a = ____________


R2
10Ω
R1
5Ω
R3
10Ω
A
1A
R4
5Ω

DC and DC Circuits
Unit 4

Assignment Sheet 14— Solve for Total Power in Series-Parallel Circuits

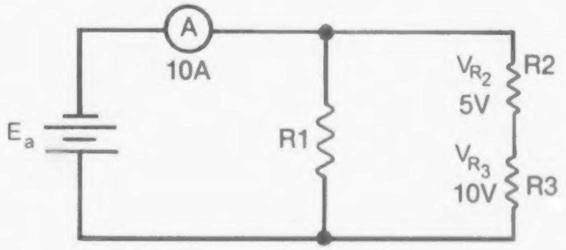
Name ______________________________ Overall Rating__________

Evaluation criteria	Rating
• Directions have been followed	________
• Minimum of 80 percent of answers are correct	________
Note: Each correct answer is worth 20 points.	

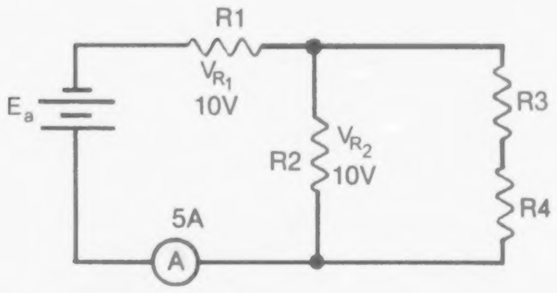
Introduction: The complexities of a series-parallel circuit complicate the process of selecting components to provide appropriate power levels. Therefore, it is important that the electronics technician understand how to compute power in these circuits. The problems below will help you to explore power relationships in series-parallel circuits.

Directions: Study the schematics below and on the next page and determine the power dissipated in each circuit or portion of the circuit as requested. Write your answers in the spaces provided with each drawing.

1. P_t = __________

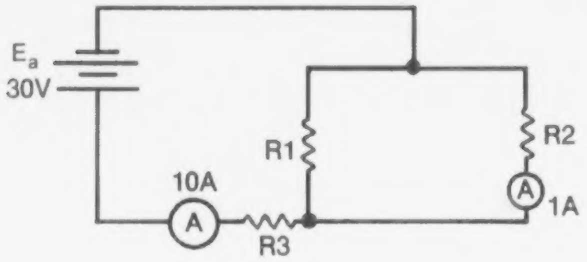


2. P_t = __________

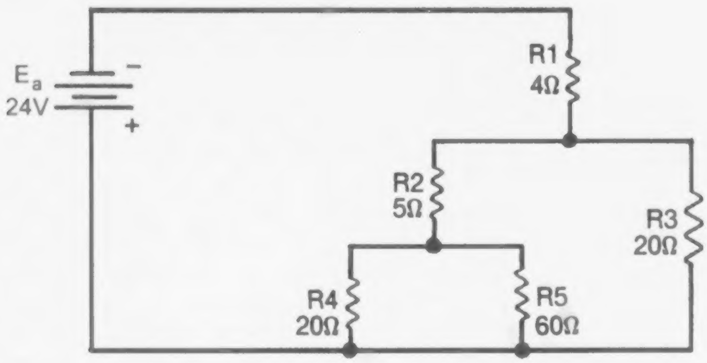


Assignment Sheet 14

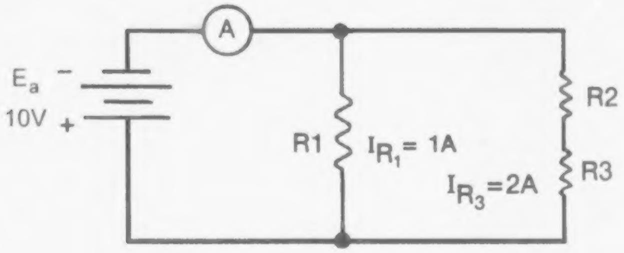
3. P_t = ____________


Ea
30V
R1
R2
10A
A
A
1A
R3

4. P_t = ____________


Ea
24V
–
+
R1
4Ω
R2
5Ω
R3
20Ω
R4
20Ω
R5
60Ω

5. P_t = ____________


A
Ea
–
10V
+
R1
I_{R_1} = 1A
R2
R3
I_{R_3}=2A

DC and DC Circuits
Unit 4

Assignment Sheet 15—Analyze DC Circuits

Name ______________________________ Overall Rating__________

Evaluation criteria	**Rating**
• Directions have been followed	________
• Minimum of 85 percent of answers are correct	________
Note: Each correct answer is worth 1.4 points.	

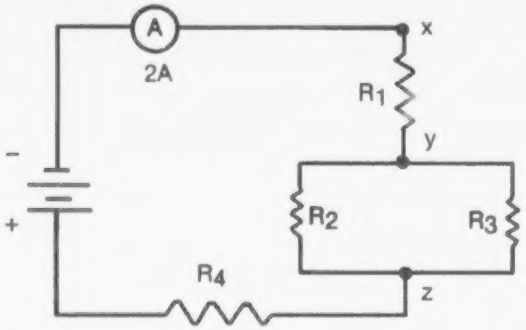
Introduction: In Unit 1, you studied the fundamentals of electricity and basic types of circuits. In this unit, you have built on that knowledge with specific applications in DC circuits. That knowledge will allow you to analyze DC circuits to determine specific characteristics and to predict the impact of changing conditions. In this assignment sheet, you will be able to demonstrate your overall understanding of DC circuits by answering questions about circuits.

Directions: This assignment sheet contains several circuits diagrams, each accompanied by a set of questions regarding the circuit. Study each circuit diagram and answer the questions that accompany it. Write your answers in the space provided with each question.

Note: The diagrams and questions begin on the next page.

Assignment Sheet 15

Note: Questions 1-5 apply to the circuit diagram below.



1. At what point in the circuit will the current divide? ______________________

2. At what point in the circuit will the current come back together? ______________

3. List the resistors in the circuit that are in a series.

   ____

4. List the resistors in the circuit that are parallel.

   ____

5. Write an "X" beside each statement below that is true of R_2 and R_3.

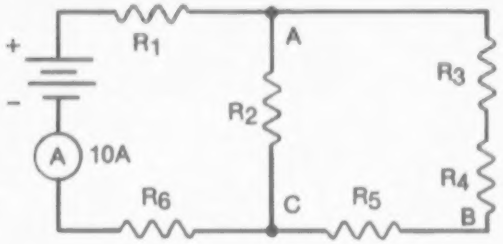
   _____a. They will carry a combined current of 2 amps.

   _____b. Each will carry 2 amps of current.

   _____c. They will carry a combined current of 1 amp.

   _____d. Each will carry **less** than 2 amps of current.

Note: Questions 6-11 apply to the circuit diagram below.



6. At what point in the circuit does the current divide? ______________________

7. At what point in the circuit will the current come back together? ______________

Assignment Sheet 15

8. Does the current divide more than once?______________________________

9. List the three resistors that form a series string.

____

10. List the resistors that are in series with the power source.

____

11. Write an "X" beside each statement below that is true of the circuit.

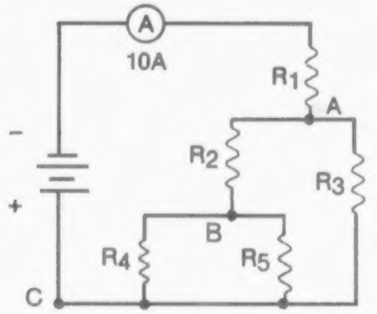
______a. R_2 is in parallel with R_3, R_4, and R_5.

______b. Less than 10 amps will flow through R_2.

______c. 10 amps will flow through R_6.

______d. Less than 10 amps will flow through R_3, R_4, and R_5.

Note: Questions 12-18 apply to the circuit diagram below.



12. At what point does the current first divide?______________________________

13. At what point does the current next divide?______________________________

14. At what point does the current all come back together?______________________________

15. Write an "X" beside each pair of resistors below that are parallel to each other in the circuit.

______a. R_1 and R_3

______b. R_2 and R_4

______c. R_2 and R_5

______d. R_4 and R_5

Assignment Sheet 15

16. How many resistors are directly in series with the rest of the circuit? ________________

17. Is the R_{eq} of R_4 and R_5 in series with R_2? ________________

18. Write an "X" beside each statement below that is true.

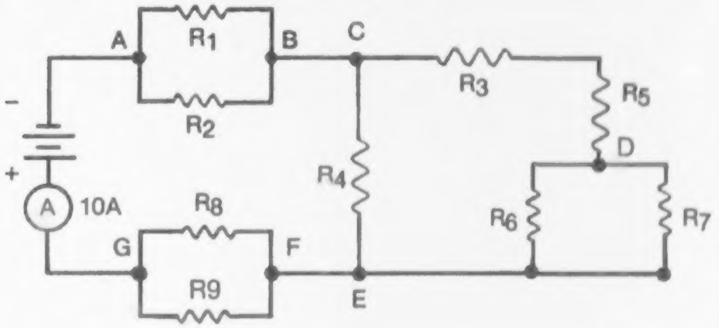
______a. $I_{R2} + I_{R3} = 10$ amps

______b. An ammeter at Point C will indicate 10 amps.

______c. Current through R_5 will be more than through R_1.

______d. $I_{R4} + I_{R5} = I_{R2}$

Note: Questions 19-30 apply to the circuit diagram below.



19. At what point does the current first divide? ________________

20. At what point does current next divide? ________________

21. Does current also divide at Point D? ________________

22. Does current also divide at Point F? ________________

23. How many resistors are in series with the power source? ________________

24. Will there be a full 10 amps of current through R_7? ________________

25. Will there be a full 10 amps of current through R_4? ________________

26. Will there be a full 10 amps of current at Point G? ________________

27. Does total current go through R_2? ________________

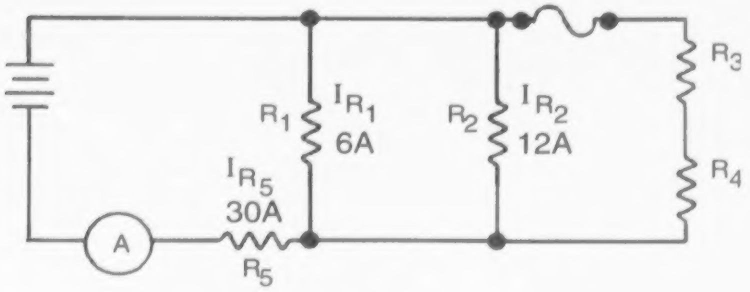
28. Does a full 10 amps enter R_9? ________________

Assignment Sheet 15

29. Will current be common through R_3 and R_5?____________________

30. Does the full 10 amps of current enter Point D?____________________

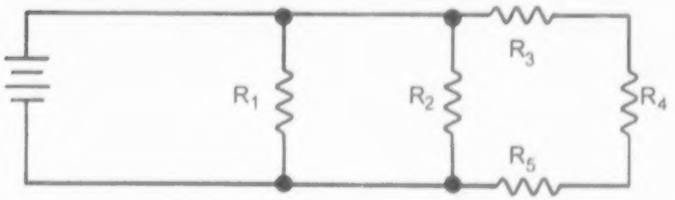
Note: Questions 31 and 32 apply to the circuit below.



31. How many amps will flow through the fuse?____________________

32. If the fuse is rated at 10 amps, will it blow?____________________

Note: Questions 33 and 34 apply to the circuit below.



33. If an open occurs between R3 and R4, what will happen to the total current? Write an "X" beside the correct answer.

    ______a. It will increase.

    ______b. It will decrease.

    ______c. It will remain the same.

34. If an open occurs between R3 and R4, what will happen to the current at R_3? Write an "X" beside the correct answer.

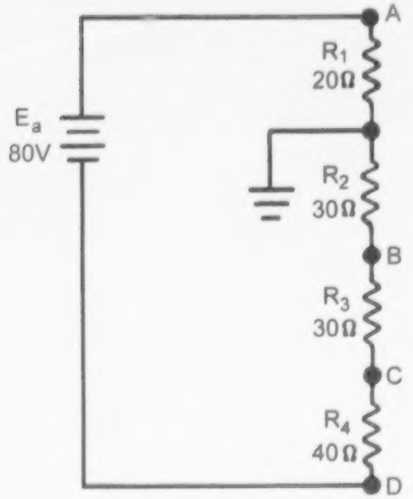
    ______a. It will increase.

    ______b. It will decrease.

    ______c. It will remain the same.

Assignment Sheet 15

Note: Questions 35-38 apply to the circuit diagram below.



35. What is the value and polarity of the voltage between Point A and ground?__________

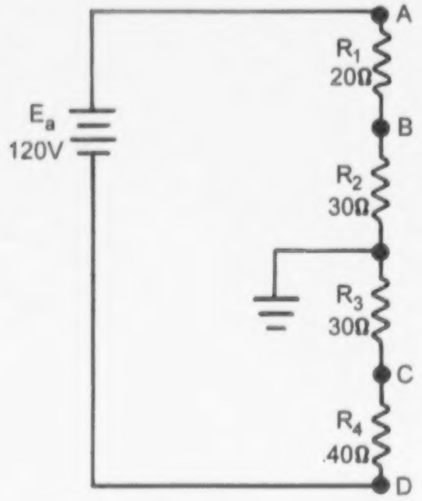
36. What is the value and polarity of the voltage between Point B and ground?__________

37. What is the value and polarity of the voltage between Point C and ground?__________

38. What is the value and polarity of the voltage between Point D and ground?__________

Assignment Sheet 15

Note: Questions 39-43 apply to the circuit diagram below.



39. What is the value and polarity of the voltage between Point A and ground?___________

40. What is the value and polarity of the voltage between Point B and ground?___________

41. What is the value and polarity of the voltage between Point C and ground?___________

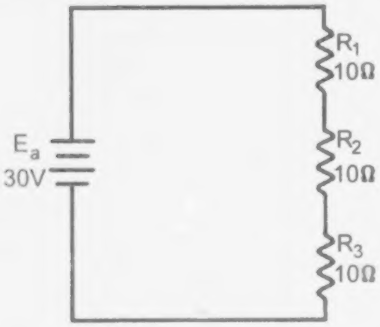
42. What is the value and polarity of the voltage between Point D and ground?___________

43. What is the value and polarity of the voltage at Point D with respect to Point A?

____

Assignment Sheet 15

Note: Questions 44-48 apply to the circuit diagram below.


E_a
30V
R_1
10Ω
R_2
10Ω
R_3
10Ω

44. R_t = ____________

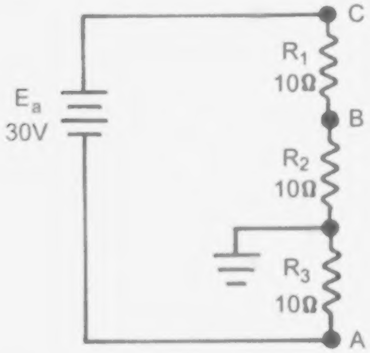
45. I_t = ____________

46. V_{R1} = ____________

47. V_{R2} = ____________

48. V_{R3} = ____________

Note: Questions 49-52 apply to the circuit diagram below. This diagram is the same as the previous except that a ground has been added.


C
R_1
10Ω
B
E_a
30V
R_2
10Ω
R_3
10Ω
A

49. What is the value and polarity of the voltage at Point A with respect to ground?

____

50. What is the value and polarity of the voltage at Point B with respect to ground?

____

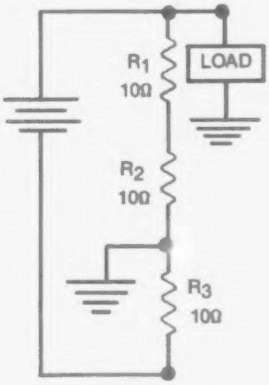
Assignment Sheet 15

51. What is the value and polarity of the voltage at Point C with respect to ground?

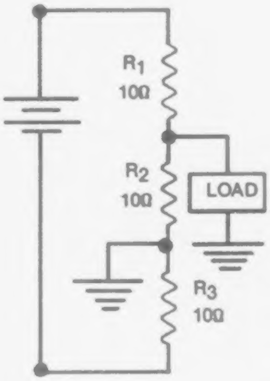
____

52. If you want to modify the circuit to add a load that operates with negative voltage, which of the following circuits shows the correct way to connect the load? Write an "X" in the space above the correct circuit.

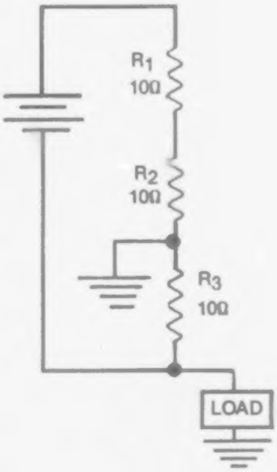
_____a.


R1
10Ω
LOAD
R2
10Ω
R3
10Ω

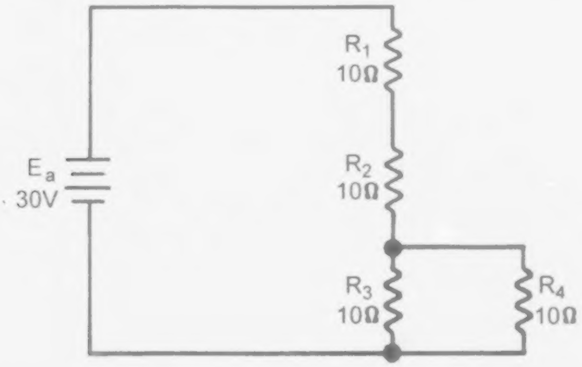
_____b.


R1
10Ω
R2
10Ω
LOAD
R3
10Ω

_____c.


R1
10Ω
R2
10Ω
R3
10Ω
LOAD

Note: Questions 53-60 apply to the circuit below. The circuit is the same as that used for Questions 44-48 with a voltage divider added.


R1
10Ω
Ea
30V
R2
10Ω
R3
10Ω
R4
10Ω

53. If the load at R_4 requires 10 volts to operate, will this circuit allow it to operate? ________

54. R_{eq} = ___________

55. R_t = ___________

Assignment Sheet 15

56. I_t = ____________

57. V_{R1} = ____________

58. V_{R2} = ____________

59. V_{R3} = ____________

60. How do the following values change when this voltage divider is added to the no-load circuit used for Questions 44-48? Will the following characteristics increase or decrease?

    a. R_t = ____________

    b. I_t = ____________

    c. E_{R1} = ____________

    d. E_{R2} = ____________

    e. E_{R3} = ____________

DC and DC Circuits
Unit 4

Job Sheet 1— Measure and Compare Current in a Circuit at Two Different Voltage Levels

Name ______________________ Attempt Number ____________

Date ______________________ Overall Rating ____________

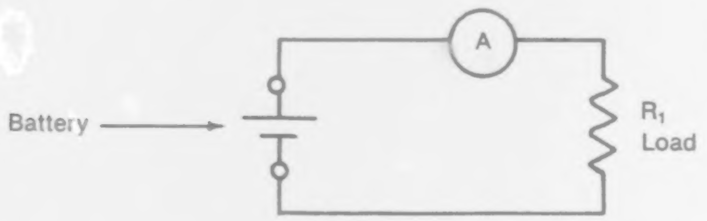
Evaluation criteria	**Rating**
• Procedures were done correctly	________
• Circuit was properly wired	________
• Measurements were accurate	________
• Student demonstrated an understanding of the applicable principles	________

Introduction: In Unit 1, you learned about types of circuits and their electrical characteristics. In Unit 2, you learned about test equipment and how to use it to measure the electrical characteristics of circuits. With this unit, you begin to put circuits to work, which requires dealing with more complex circuits. In this first Job Sheet, you will analyze the effects on current when the voltage level in a DC circuit is changed.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Multimeter or equivalent individual meters
- DC ammeter
- DC power supply or two 1.5-volt batteries
- 2.2-volt lamp and socket
- Low-voltage conductor
- Mounting surface and hardware
- Pencil and paper
- Circuit drawing



Job Sheet 1

B. Procedure

☐ 1. Measure and record the resistance of the lamp.

☐ 2. Assemble circuit per drawing, but do **not** apply power.

☐ 3. Calculate and record the expected current if the applied voltage is 1.5 volts.

☐ 4. Apply power using one 1.5-volt battery or with the power supply set to 1.5 volts.

☐ 5. Measure and record the circuit amperage.

☐ 6. Remove power from the circuit.

☐ 7. Calculate and record the expected current if the applied voltage is 3.0 volts.

☐ 8. Apply power using two 1.5-volt batteries or with the power supply set to 3.0 volts.

☐ 9. Measure and record the circuit amperage.

☐ 10. Remove power from the circuit.

☐ 11. Reverse the polarity of the power source.

☐ 12. Apply power using two 1.5-volt batteries or with the power supply set to 3.0 volts.

☐ 13. Measure and record the circuit amperage.

☐ 14. Remove power from the circuit.

☐ 15. Consider the following points and record your responses:

- What happened to the current when the voltage was increased?
- Did the circuit exhibit the current value that you calculated for 1.5 volts?
- Did the circuit exhibit the current value that you calculated for 3.0 volts?
- If the current value for one or both of the voltages was different than what you calculated, what is the most probable explanation for the difference?
- If you did not observe the expected current values, what kind of troubleshooting actions could you take to determine whether your probable explanation is correct?

Job Sheet 1

- Did reversing the polarity of the power supply affect the current value? Why or why not?
- Was there an observable difference in the brightness of the lamp when the voltage was increased?

☐ 16. Disassemble circuit and return equipment and materials to their proper storage location.

Evaluator's comments:____

____

____

____

DC and DC Circuits
Unit 4

Job Sheet 2— Wire a Functional Relay Circuit

Name ______________________ Attempt Number ____________

Date ______________________ Overall Rating ____________

Evaluation criteria	Rating
• Procedures were done correctly	________
• Circuit was properly wired	________
• Measurements were accurate	________
• Student demonstrated an understanding of the applicable principles	________

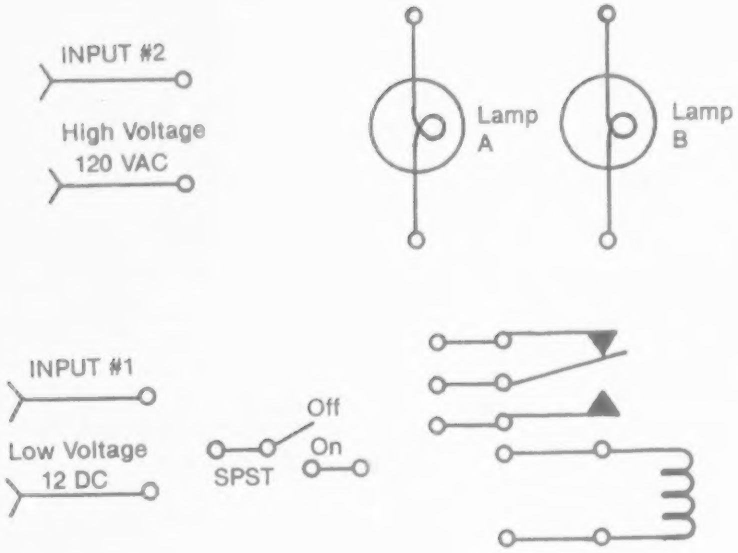
Introduction: A relay is a switch that is actuated by a signal. Relays may be electromechanical or electronic. They are useful devices because they can control circuit operation based on changing conditions. In this job sheet, you will be provided with a description of how a relay circuit must operate and be asked to design the circuit that will provide those functions. This is a typical requirement that electronic technicians and engineers face.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Low-voltage, double-pole, single-throw (DPST) relay
- Single-pole, single-throw (SPST) switch
- 120-volt AC power supply
- Two 120-volt lamps
- Two lamp sockets
- Low-voltage conductor
- Mounting surface and hardware
- Pencil and paper
- Circuit drawing

Job Sheet 2



B. Procedure

☐ 1. Complete the circuit drawing so that the circuit will provide the following functional response:

- With the SPST switch in the *on* position, Lamp A will be on and Lamp B will be off
- With the SPST switch in the *off* position, Lamp A will be off and Lamp B will be on

☐ 2. Wire the circuit with the SPST switch in the *off* position, but do **not** apply power to the power supply.

☐ 3. Explain your circuit design and operation to your instructor.

☐ 4. Apply power to the power supply.

☐ 5. Verify that Lamp A is off and Lamp B is on.

☐ 6. Place the SPST switch to the *on* position and verify that Lamp A is on and Lamp B is off.

☐ 7. Describe a practical application of this circuit to your instructor.

Note: The application must be more than just using lights to show the SPST switch position because a single lamp (either on or off) could be used to do that.

Job Sheet 2

☐ 8. Remove power from the circuit.

☐ 9. Disassemble circuit and return equipment and materials to their proper storage location.

Evaluator's comments:____

DC and DC Circuits
Unit 4

Job Sheet 3— Measure the Voltage Drop in a DC Circuit

Name ______________________ Attempt Number ____________

Date ______________________ Overall Rating ____________

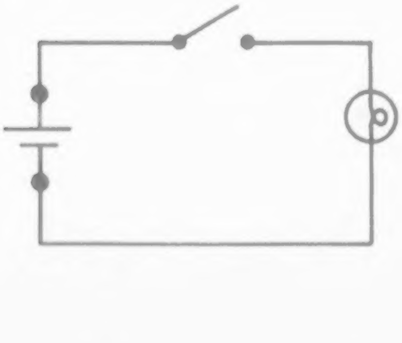
Evaluation criteria	**Rating**
• Procedures were done correctly	______
• Circuit was properly wired	______
• Measurements were accurate	______
• Student demonstrated an understanding of the applicable principles	______

Introduction: By applying Kirchhoff's voltage law, an electronics technician should be able to predict expected voltages at various points in a circuit. One possible indication of a circuit problem is a difference between predicted and measured voltages and voltage drops. In this job sheet, you will predict and measure voltage drops and analyze circuit operation based on your observations.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Voltmeter or multimeter
- Adjustable DC power supply
- 2.2-volt lamp and socket
- SPST switch
- Low-voltage conductor
- Mounting surface and hardware
- Pencil and paper
- Circuit drawing



Job Sheet 3

B. Procedure

☐ 1. Assemble circuit per drawing, but do **not** apply power.

☐ 2. Close the switch.

☐ 3. Measure the voltage across the terminals of the power supply and adjust to 3.0 volts.

☐ 4. Calculate the voltage drop across the lamp and record your answer.

☐ 5. Measure the voltage drop across the lamp and record your measurement.

☐ 6. Compare the measured voltage drop with your predicted voltage drop and explain in writing why they are or are not the same.

☐ 7. Measure the voltage drop across the switch and record your measurement.

☐ 8. Compare your predicted voltage drop for the circuit with the sum of the voltage drops measured for the switch and the lamp; explain in writing why they are or are not the same.

☐ 9. Open the switch.

☐ 10. Predict the voltage drop across the switch with the switch open and record your answer.

☐ 11. Measure the voltage drop across the switch and record your measurement.

☐ 12. Compare your predicted voltage drop with the measured voltage drop and explain in writing why they are or are not the same.

☐ 13. Remove power from the circuit.

☐ 14. Disassemble circuit and return equipment and materials to their proper storage location.

Evaluator's comments:____

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DC and DC Circuits
Unit 4

Job Sheet 4— Construct a Voltage Divider and Analyze Its Function

Name ______________________ Attempt Number ____________

Date ______________________ Overall Rating ____________

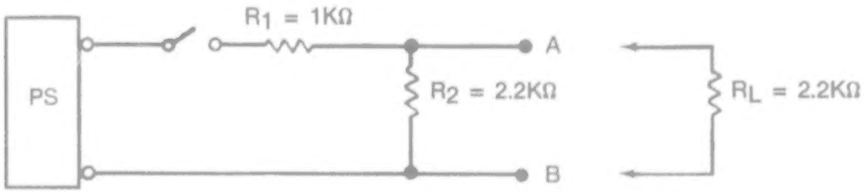
Evaluation criteria	Rating
• Procedures were done correctly	______
• Circuit was properly wired	______
• Measurements were accurate	______
• Student demonstrated an understanding of the applicable principles	______

Introduction: Voltage dividers are used to tap a circuit to create a branch circuit with a specific voltage. This is normally done by assembling a resistive circuit to produce a desired voltage drop so that the output voltage is equal to the required amount. In this job sheet, you will apply what you have learned about voltage drops and DC circuitry to construct a simple voltage divider and analyze its operation.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Multimeter
- DC power supply
- One 1 Kohm resistor, 1/2-watt or more
- Two 2.2 Kohm resistors, 1/2-watt or more
- SPST switch
- Low-voltage conductor
- Mounting surface and hardware
- Pencil and paper
- Circuit drawing



Job Sheet 4

B. Procedure

☐ 1. Assemble circuit per drawing, but do **not** apply power.

☐ 2. Set the power supply to 20 volts.

☐ 3. Close the switch.

☐ 4. Measure and record the voltage drop for R_1.

☐ 5. Measure and record the voltage drop for R_1.

☐ 6. Connect the load to terminals A and B.

☐ 7. Repeat Steps 4 and 5.

☐ 8. Write out your answers to the following questions:

- What is the relationship between R_1 with and without the load resistance connected?
- What is the relationship between R_2 with and without the load resistance connected?
- With the load connected, does this circuit operate as a series circuit, a parallel circuit, or a series parallel circuit and what tells you that this is the case?
- What resistor values for R_1, R_2, and R_3 would you use if you wanted to build the same circuit so that the voltage output of the divider circuit was one-fourth of the applied voltage?
- How could a potentiometer be useful in a voltage divider circuit?
- Does the current you built provide a possible example of a potentiometer used as a voltage divider?

☐ 9. Remove power from the circuit.

☐ 10. Disassemble circuit and return equipment and materials to their proper storage location.

Evaluator's comments:____

____

____

____

DC and DC Circuits
Unit 4

Job Sheet 5— Measure Voltages in a Balanced Bridge Circuit

Name ______________________________ Attempt Number ____________

Date ______________________________ Overall Rating ____________

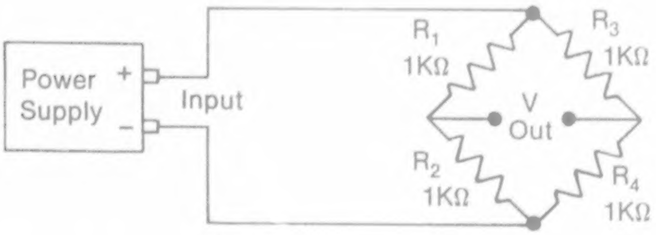
Evaluation criteria	**Rating**
• Procedures were done correctly	________
• Circuit was properly wired	________
• Measurements were accurate	________
• Student demonstrated an understanding of the applicable principles	________

Introduction: Bridge devices are useful in control and instrumentation circuits and other applications. One type of bridge circuit is called the balanced bridge circuit. The balanced bridge circuit demonstrates the principles of bridge circuit operation. In this job sheet, you will build and operate a balanced bridge circuit.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Voltmeter or multimeter
- DC power supply
- Four 1 Kohm resistors, 1/2-watt or more
- Low-voltage conductor
- Mounting surface and hardware
- Pencil and paper
- Circuit drawing



Job Sheet 5

B. Procedure

☐ 1. Assemble circuit per drawing, but do **not** apply power.

☐ 2. Set the power supply to 10 volts.

☐ 3. Measure and record the voltage drop for R_1.

☐ 4. Repeat Step 3 for the other resistors.

☐ 5. Predict and record the value for bridge voltage output.

☐ 6. Measure and record the voltage output.

☐ 7. Write out your answers to the following questions:

- Was your prediction of the output voltage correct? If not, what is the explanation for the difference between your prediction and the measured value?
- Would the output value change if you replace R_2 and R_4 with 2 Kohm resistors?
- Would the output value change if you replace R_3 and R_4 with 2 Kohm resistors?
- Would the output value change if you use a 4 Kohm resistor in R_1, a 2 Kohm resistor in R_2, a 6 Kohm resistor in R_3 and a 3 Kohm resistor in R_4?

☐ 8. Remove power from the circuit.

☐ 9. Disassemble circuit and return equipment and materials to their proper storage location.

Note: This circuit can be used for Job Sheet 6. Ask your instructor if you should leave it assembled and continue with Job Sheet 6.

Evaluator's comments:____

DC and DC Circuits
Unit 4

Job Sheet 6— Measure Voltages in an Unbalanced Bridge Circuit

Name ______________________ Attempt Number __________

Date ______________________ Overall Rating __________

Evaluation criteria	**Rating**
• Procedures were done correctly	________
• Circuit was properly wired	________
• Measurements were accurate	________
• Student demonstrated an understanding of the applicable principles	________

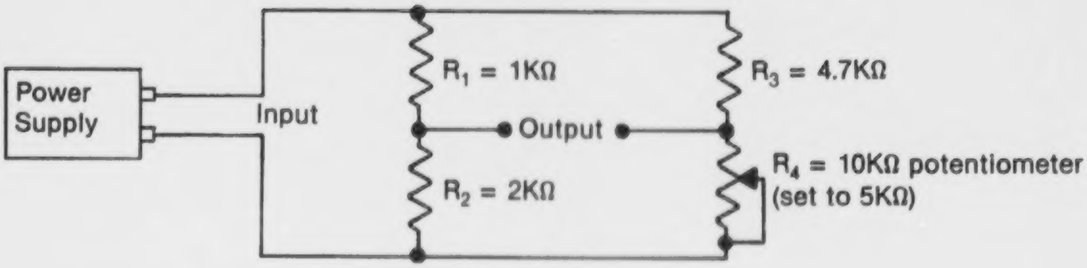
Introduction: In Job Sheet 5, you constructed and operated a balanced bridge circuit. If the resistor values of the two branches is not equal, then the circuit becomes an *unbalanced bridge*. This job sheet deals with the operation of an unbalanced bridge circuit.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Voltmeter or multimeter
- DC power supply
- Two 1 Kohm resistors, 1/2-watt or more
- One 4.7 Kohm resistor, 1/2-watt or more
- Decade box or 10 Kohm potentiometer
- Low-voltage conductor
- Mounting surface and hardware
- Pencil and paper
- Graph paper
- Circuit drawing

Job Sheet 6



B. Procedure

☐ 1. Assemble circuit per drawing, but do **not** apply power.

☐ 2. Prepare graph coordinates on the graph paper as follows:

- Label the y-axis (vertical) "Output in Volts" and number it 0 through 12
- Label the x-axis (horizontal) "Potentiometer Setting in Kohms" and number it 0 through 10

☐ 3. Set the potentiometer to 1 Kohm.

☐ 4. Set the power supply to 12 volts and energize the circuit.

☐ 5. Measure and record the voltage drop for R_1.

☐ 6. Repeat Step 3 for the other resistors, including the potentiometer.

☐ 7. Measure the voltage out of the circuit.

☐ 8. Plot the voltage output to show the value for the setting of the potentiometer.

Note: The first plot point should be above the horizontal axis over the 1 and opposite the vertical axis even with the voltage reading you obtained. Record the voltage reading to the nearest tenth of a volt and estimate the position between each whole number.

☐ 9. Change the potentiometer to 2 Kohms.

☐ 10. Repeat Steps 5-8 to measure the specified values and to plot the voltage output for the new potentiometer setting.

☐ 11. Continue increasing the potentiometer setting in 1-Kohm increments and making the measurements and recordings required by Steps 5-8 until you have plotted output values for potentiometer settings of 1 through 10 Kohms.

Job Sheet 6

☐ 12. Write out your answers to the following questions:

- Did the voltage drops across the other resistors change as the potentiometer was adjusted? Why or why not?
- What happened to the output value as the potentiometer was adjusted?
- Based on your experience and your graph, what would you predict the output to be when the potentiometer is set at 4.7 Kohms?

☐ 13. Remove power from the circuit.

☐ 14. Disassemble circuit and return equipment and materials to their proper storage location.

Note: This circuit can be used for Job Sheet 7. Ask your instructor if you should leave it assembled and continue with Job Sheet 7.

Evaluator's comments:____

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DC and DC Circuits
Unit 4

Job Sheet 7—Construct and Operate a Wheatstone Bridge Circuit

Name ______________________ Attempt Number ____________

Date ______________________ Overall Rating ____________

Evaluation criteria	**Rating**
• Correct procedures were followed	________
• Circuit was configured properly	________
• Equipment was used correctly	________
• Correct values were obtained	________

Introduction: One practical configuration of a bridge circuit is called a *wheatstone bridge*. Your work in the previous two job sheets has shown you that the output of a bridge circuit is dependent on the ratio of resistances in the two branch circuits. The graph that you made in Job Sheet 6 could actually be used to develop a formula with practical application for determining unknown resistances. Using the circuit diagram in Job Sheet 6, if we substitute a resistor of unknown value for R_3, we can determine its value by adjusting the potentiometer so that the voltage output of the bridge circuit is 0 volts. This is true because we have created a balanced bridge, with R_1 and R_2 having the same ratio as R_3 and R_4 (1:1). This can be expressed in the formula:

$$R_x = R_4 \times \frac{R_2}{R_1}$$, where R_x is the resistor with the unknown value substituted for R_3.

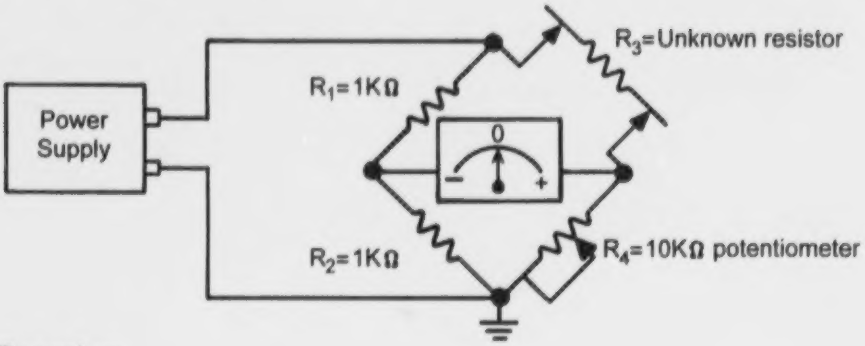
Because R_1 and R_2 are equal, they can be eliminated from the formula as they will reduce to 1 no matter what their values are. In this job sheet, you will construct a wheatstone bridge and use it to determine the values of resistors whose values are not known.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Voltmeter or galvanometer
- DC power supply
- Two 1 Kohm resistors, ½-watt or more
- Three resistors of unknown values provided by your instructor and labeled as A, B, and C
- Decade box or 10-Kohm potentiometer (calibrated)

- Low-voltage conductor
- Mounting surface and hardware
- Pencil and paper
- Circuit drawing



B. Procedure

☐ 1. Assemble circuit per drawing with Resistor A installed in R_3, but do **not** apply power.

☐ 2. Set the power supply to 10 volts and energize the circuit.

☐ 3. Adjust the potentiometer until the galvanometer reads zero.

☐ 4. Check the setting of the potentiometer and record this value as the resistance of the resistor being measured.

☐ 5. Remove power from the circuit.

☐ 6. Repeat Steps 1-5 with Resistors B and C.

☐ 7. Return the marked resistors to your instructor and discuss your results.

☐ 8. Disassemble circuit and return equipment and materials to their proper storage location.

Evaluator's comments:____

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DC and DC Circuits
Unit 4

Job Sheet 8— Determine the Maximum Power Transfer Point on a Resistor Circuit

Name ______________________ Attempt Number ____________

Date ______________________ Overall Rating ____________

Evaluation criteria	**Rating**
• Equipment was set up correctly	________
• Correct procedures were followed	________
• Waveform presentation was clear and stable	________

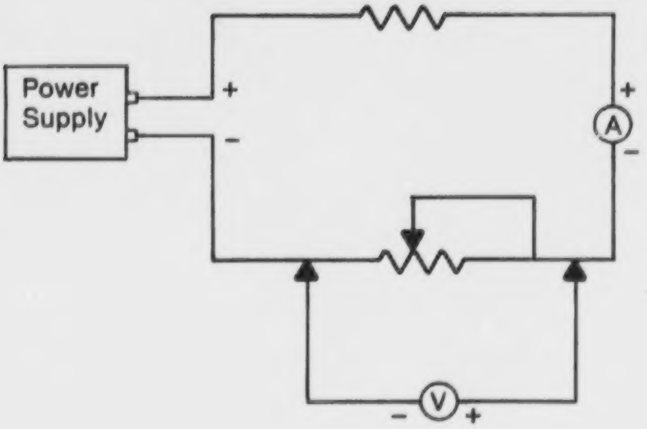
Introduction: In Unit 1, you studied the principle of maximum power transfer. According to this theorem, the maximum rate of power transfer occurs when the resistance of the load is equal to the internal resistance of the power source. In this job sheet, you will build and test a circuit to determine the resistance value of the circuit that will produce maximum power transfer.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Multimeter
- Ammeter
- Test leads
- DC power supply
- One 200 ohm resistor, 1/2-watt or more
- Potentiometer, 0 to 400 ohms (or larger)
- Low-voltage conductor
- Mounting surface and hardware
- Pencil and paper
- Graph paper
- Circuit drawing

Job Sheet 8



B. Procedure

☐ 1. Assemble circuit per drawing, but do **not** apply power.

☐ 2. Prepare graph coordinates on the graph paper as follows:

- Label the y-axis (vertical) "Power to the Potentiometer in Watts" and number it so that 0 is the bottom of the scale and 1 is the top of the scale.
- Label the x-axis (horizontal) "Parallel Meter Voltage" and number it 0 through 7.

☐ 3. Set the potentiometer to 0.

☐ 4. Set the ammeter to measure 0.05 amperes DC near the limit of the scale.

☐ 5. Set the multimeter to measure from 0 to 10 volts DC.

☐ 6. Set the power supply to 10 volts and energize the circuit.

☐ 7. Measure the voltage across the potentiometer and note the reading.

Note: The initial reading should be near 0.

☐ 8. Calculate the wattage by multiplying the multimeter reading by the ammeter reading.

Note: The calculated amount should be a decimal fraction of a watt.

☐ 9. Plot the power value on the graph.

Note: The first plot point should be above the horizontal axis over the 0 and on the vertical axis even with the power that you calculated. Record the power reading to the nearest hundredth of a watt and estimate the position between each segment of your graph.

Job Sheet 8

☐ 10. Adjust the potentiometer until the multimeter reading is 1.0 volt.

☐ 11. Repeat Steps 8 and 9 for the new power value.

☐ 12. Continue to adjust the potentiometer, calculate power, and plot values on the graph for each 1-volt increment to 7 volts.

☐ 13. Note the peak wattage and label this point on your graph as "Maximum Power Transfer."

☐ 14. Remove power from the circuit.

☐ 15. Disassemble circuit and return equipment and materials to their proper storage location.

Evaluator's comments:____

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DC and DC Circuits
Unit 4

Job Sheet 9— Test and Replace Cells

Name ______________________________ Attempt Number ____________

Date ______________ ______________ Overall Rating ____________

Evaluation criteria	**Rating**
• Equipment was set up correctly	________
• Correct procedures were followed	________
• Batteries were classed correctly as to serviceability	________

Introduction: Because of the need to use DC to power electronic devices and the popularity of portable electronic equipment, batteries are often used as power sources in the electronics industry. Therefore, it is important that the electronics technician be able to verify that batteries are operating correctly. Batteries consist of cells, and, depending on the design of the battery, testing these power sources may be done at the cell level. This job sheet covers two types of battery tests. The first is the voltage test. The second is the specific gravity test often used on wet-cell batteries, such as those commonly used in automobiles. Due to the ever-increasing use of electronics in the automotive industry, more and more electronic technicians are finding work in this specialty field.

The voltage test requires that you calculate the internal resistance of the battery. This is done using the following formula:

$$R_i = \frac{V_{unloaded} - V_{loaded}}{I}$$

In this job sheet, we will use certain criteria for accepting or rejecting a battery. However, in actual practice, evaluation of batteries tends to be more subjective. As battery charge decreases, equipment performance may be affected. For example, a battery with a low state of charge may cause a cassette tape to play slowly, affecting the sound quality. Similarly, a low charge may cause equipment indicators to be too dim to detect.

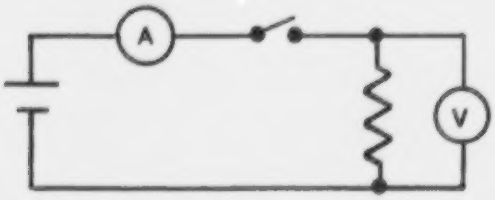
A low state of charge also affects battery life. Thus, if equipment is difficult to access—such as a communications satellite—a technician would want to make sure that batteries used in the equipment have the longest life possible when they are installed. Thus, batteries with 80 percent of their maximum charge may be acceptable for use with a flashlight but unacceptable for use in a smoke detector at the peak of a 30-foot ceiling.

Job Sheet 9

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Hydrometer
- Ammeter
- Multimeter
- Test leads
- Dry-cell batteries or cells of various voltages and chemical types
- 1 Kohm resistor
- 6- or 12-volt lead-acid, wet-cell battery
- SPST switch
- Low-voltage conductor
- Mounting surface and hardware
- Cloth
- Pencil and paper
- Battery tables at end of job sheet
- Circuit drawing



B. Procedure for voltage test

☐ 1. Assemble the circuit per the drawing, leaving the switch open.

☐ 2. Use the multimeter to measure the unloaded voltage output of a dry-cell battery and record the reading.

☐ 3. Close the switch.

☐ 4. Measure and record the loaded voltage.

☐ 5. Measure and record the current.

☐ 6. Calculate the internal resistance of the battery.

☐ 7. Compare the internal resistance reading to Table 1 at the end of this job sheet.

Note: Be sure to use the correct cell size.

Job Sheet 9

☐ 8. If the internal resistance is 75 percent or more of the listed value, accept the battery as good and continue the procedure; if the resistance is 74 percent or less of the listed value, reject the battery and go to Step 14 to complete the procedure or go back to Step 2 to test the next battery.

☐ 9. Compare the no-load voltage of the battery or cell to that listed in Table 2 for the type of cell being tested.

☐ 10. If the no-load voltage is 75 percent or more of the listed value, accept the battery as good and continue the procedure; if the voltage is 74 percent or less of the listed value, reject the battery and go to Step 14 to complete the procedure or go back to Step 2 to test the next battery.

Note: If the voltage requirements of the equipment in which the batteries will be used are known, use those as the acceptance criteria.

☐ 11. Compare the loaded voltage of the battery or cell to that listed in Table 2 for the type of battery being tested.

☐ 12. If the loaded voltage is 75 percent or more of the listed value, accept the battery as good and continue the procedure; if the voltage is 74 percent or less of the listed value, reject the battery and go to Step 14 to complete the procedure or go back to Step 2 to test the next battery.

☐ 13. If other batteries are to be tested, repeat Steps 2-12 as required; otherwise, continue with the procedure.

☐ 14. Remove power from the circuit.

☐ 15. Disassemble circuit and return equipment and materials to their proper storage location.

C. Procedure for specific gravity test

☐ 1. Wipe off the top of the wet-cell battery with a cloth to prevent dirt and contaminants from entering the cells.

☐ 2. Remove the cap from one cell.

Caution: Battery acid is dangerous and can burn your skin and eyes, as well as clothing and other materials. Be careful not to spill or drip the battery electrolyte and do not blow into the cells or squeeze air from the hydrometer into the cells.

☐ 3. Check the electrolyte level in the cell and fill as required following the battery manufacturer's recommendations.

Job Sheet 9

☐ 4. Compress the bulb on the hydrometer and insert it into the cell.

☐ 5. Release the bulb and allow the hydrometer syringe to fill with electrolyte.

☐ 6. Remove the hydrometer from the battery and record the reading on the graduated scale on the hydrometer.

Note: The number represents the *specific gravity* of the electrolyte, which is basically the weight of the electrolyte compared to the weight of an equal volume of water. For example, a reading of 1.25 means that the electrolyte weighs one-and-one-fourth times as much as an equal volume of water.

☐ 7. Return electrolyte to the battery cell and replace the cap.

☐ 8. Compare the reading to the values presented in Table 3 or to the table provided with the hydrometer.

Note: Some specific gravity tables are based on the electrolyte being at a given temperature and require you to add or subtract an amount to correct the reading for different temperatures.

☐ 9. If the battery tests near 100 percent, proceed to Step 14; otherwise continue to Step 10.

☐ 10. Determine the expected state of charge for the battery.

Note: Batteries that are part of a self-charging system, such as most vehicles, and those that have been recently charged should be very near 100 percent of charge, though this percentage will drop as the battery ages. Batteries that have been in storage or that have been drained without recharging may show a low state of charge but may be serviceable.

☐ 11. Attempt to charge the battery using the battery or vehicle manufacturer's recommended procedures.

Caution: Do not attempt to charge a battery without first receiving instruction on the procedure and the use of the charging equipment. If the battery that you are testing requires charging, discuss the situation with your instructor to detemine how to handle it in your facility.

Job Sheet 9

☐ 12. Once the battery has been charged, repeat Steps 1-9 to verify that the charge was successful.

☐ 13. If the battery fails to charge, label the battery as bad and return it to your instructor.

☐ 14. Repeat Steps 2-13 as required for the other cells.

☐ 15. Return equipment and materials to their proper storage location.

Evaluator's comments: ____________________

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Job Sheet 9

Table 1: Internal resistance for various sizes of cells

CELL CHARACTERISTICS			
Cell Size	**Internal Resistance (Ohms)**	**Current Drain(mA)**	**Life (Hours)**
N	0.69	1.5	275
		7.5	52
		15	24
AA	0.29	3	350
		15	41
		30	15
AAA	0.44	2	290
		10	45
		20	17
C	0.47	5	420
		25	100
		50	40
D	0.27	10	500
		50	105
		100	45

Table 2: Typical cell voltage ratings

TYPICAL CELL VOLTAGE RATINGS			
	Voltage Ratings		
Type of Cell	**No Load**	**Loaded**	**Discharged**
Copper-zinc sulfuric acid, primary wet cell	1.08	1.008	0.8
Carbon-zinc-chromic acid, primary wet cell	2.0	1.9	1.7
Carbon-zinc-ammonium chloride, primary dry cell	1.5	1.4	1.2
Mercury-zinc-potassium hydroxide, primary dry cell	1.34	1.31-1.24	1.0
Lead-acid storage cell	2.1	2.0	1.75
Nickel-iron, alkaline storage cell	1.37	1.3	1.0
Nickel-cadmium, alkaline storage cell	1.3	1.2	1.0
Silver-zinc, alkaline storage cell	1.95	1.86	1.6

Job Sheet 9

Table 3: State of charge based on specific gravity readings

SPECIFIC GRAVITIES		
From	**To**	**Charge**
1.260	1.280	100%
1.230	1.250	75%
1.200	1.220	50%
1.170	1.190	25%
1.140	1.160	Very little useful capacity
1.110	1.130	Discharged

DC and DC Circuits
Unit 4

Job Sheet 10— Test and Replace Lamps

Name ______________________ Attempt Number ____________

Date ______________________ Overall Rating ____________

Evaluation criteria	**Rating**
• Procedure was done correctly	________
• Equipment was used correctly	________
• Lamp status was correctly identified	________

Introduction: Lamps are used extensively in electronic equipment for indicators, displays, illumination for meters, etc. They often play a critical role in troubleshooting equipment problems because they may indicate an equipment problem and a failed lamp may indicate a problem that does not exist. Because lamps are generally easy to check, testing them is a worthwhile step in the troubleshooting process to confirm that indications are correct and as a way of verifying a known-good component.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Ohmmeter
- Continuity light
- Various types of lamps as provided by your instructor

B. Procedure

☐ 1. Select the lamp to be tested.

☐ 2. Determine lead construction of the lamp.

Note: Some lamps will have separate leads, while others will have a lead at the base of the lamp and will use the case of the lamp to provide the second lead.

☐ 3. Touch the negative probe of the ohmmeter to one lead and the positive probe to the other lead.

Note: If using a continuity tester, touch one probe to each lamp lead and check for continuity.

Job Sheet 10

☐ 4. Check the ohmmeter reading.

☐ 5. If the ohmmeter reading is near 0, accept the lamp; if the ohmmeter reading is near ∞, reject the lamp.

Note: If using a continuity tester, accept the lamp if continuity exists and reject it if there in no continuity.

☐ 6. Repeat Steps 1-5 for next lamp or continue to Step 7 if all lamps have been tested.

☐ 7. Return equipment and materials to their proper storage location.

Evaluator's comments:____

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DC and DC Circuits
Unit 4

Job Sheet 11— Test and Replace Switches

Name ______________________ Attempt Number ____________

Date ______________________ Overall Rating ____________

Evaluation criteria	Rating
• Procedure was done correctly	________
• Equipment was used correctly	________
• Switch status was correctly identified	________

Introduction: The purpose of a switch, no matter what its design, is to complete one or more circuits in a given position and to break one or more circuits in other positions. Additionally, there must be a means of changing the switch position, which actuation may be mechanical, electrical, thermal, gravity-actuated, buoyancy-actuated, or driven by some other force. For a switch to operate correctly, then, it must satisfy two requirements: it must complete or break the circuit as required and it must respond correctly to the actuating force. In this job sheet, you will test the operation of several types of manually operated switches.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Ohmmeter or continuity light
- Various types of switches provided by your instructor
- Test leads

B. Procedure

☐ 1. Select the switch to be tested.

☐ 2. Determine its *on* and *off* positions.

☐ 3. Set the switch to an *off* position.

☐ 4. Place one probe of the ohmmeter or continuity light on the input lead for the set position.

☐ 5. Place the other probe on the output lead for the set position.

☐ 6. Verify that the ohmmeter shows ∞ or that the continuity light is not illuminated.

Job Sheet 11

☐ 7. Repeat Steps 3-6 for any other *off* positions.

☐ 8. Set the switch to an *on* position.

☐ 9. Place one probe of the ohmmeter or continuity light on the input lead for the set position.

☐ 10. Place the other probe on the output lead for the set position.

☐ 11. Verify that the ohmmeter shows 0 or that the continuity light is illuminated.

☐ 12. Repeat Steps 8-11 for any other *on* positions.

☐ 13. If all responses were correct, accept the switch; if the switch failed in any position, reject or repair it.

☐ 14. Repeat Steps 1-13 for other switches.

☐ 15. Return equipment and materials to their proper storage location.

Evaluator's comments:____

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DC and DC Circuits
Unit 4

Job Sheet 12— Test and Replace Resistors

Name ______________________ Attempt Number ____________

Date ______________________ Overall Rating ____________

Evaluation criteria	Rating
• Procedure was done correctly	________
• Equipment was used properly	________
• Resistor status was correctly identified	________

Introduction: One of the most common components used in electronic equipment is the resistor. Some circuits are especially sensitive to resistance as a factor in correct operation. Consequently, a circuit failure may result from a resistor failing to provide resistance within the circuit requirements. Resistors are manufactured with tolerances—that is, with a range of values. For example, a 1 Kohm resistor may have a tolerance of ± 10%, meaning that the resistor should provide a resistance of between 900 and 1100 ohms. This job sheet describes how to verify that resistors are performing within their specified tolerances.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Multimeter
- Test leads
- Data sheets for resistors
- Various resistors provided by your instructor
- Paper and pencil

B. Procedure

☐ 1. Prepare a table to record the results of your testing with the following column headings:

- Resistor Number
- Rated Value
- Tolerance
- Measured Resistance
- Acceptable (Yes or No)

Job Sheet 12

☐ 2. Under the "Resistor Number" heading, list each resistor to be tested.

☐ 3. Under the "Rated Value" heading, list the rated value of each resistor beside the proper resistor number.

Note: Use the color coding, labeling, or data sheet to determine the rated value and tolerance. For variable resistor, list the range.

☐ 4. Under the "Tolerance" heading, list the tolerance of each resistor beside the proper resistor number.

☐ 5. Select the resistor to be tested.

☐ 6. With the multimeter set up to measure resistance, touch one probe of the multimeter to one lead of the resistor.

☐ 7. Touch the other probe to the other lead.

☐ 8. Observe and record the measured value of the multimeter under the "Measured Resistance" heading beside the proper resistor number.

☐ 9. If the resistor being tested is a fixed resistor, proceed to Step 13; if the resistor being tested is a variable resistor, continue with Step 10.

☐ 10. Touch one probe of the multimeter to the output lead of the resistor.

☐ 11. Touch the other probe to the variable lead.

☐ 12. Actuate the variable resistor to cause changes in resistance values and observe the multimeter, noting whether the resistance value increases and decreases smoothly in appropriate response to the movement of the variable lead.

☐ 13. Compare the measured value to the rated value with tolerance allowances.

☐ 14. If the measured resistance is not within the acceptable range, record an "N" under the "Accept" heading beside the proper resistor number and go to Step 18.

☐ 15. If the resistor is within the acceptable range, go to Step 18 for fixed resistors or go to Step 16 for variable resistors.

☐ 16. If the variable resistor did not show smooth resistance changes as the variable lead moved, record an "N" under the "Accept" heading beside the proper resistor number and go to Step 18.

☐ 17. If the variable resistor showed smooth resistance changes as the variable lead moved, record a "Y" under the "Accept" heading beside the proper resistor number and go to Step 18.

Job Sheet 12

☐ 18. Repeat Steps 5-17 as required to test remaining resistors.

☐ 19. Return equipment and materials to their proper storage location.

Evaluator's comments:____

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DC and DC Circuits
Unit 4

Job Sheet 13— Test and Replace Fuses and Circuit Breakers

Name ______________________ Attempt Number ______________

Date ______________________ Overall Rating ______________

Evaluation criteria	**Rating**
• Procedure was done correctly	________
• Equipment was used correctly	________
• Device status was correctly identified	________

Introduction: In Unit 2, you studied how to fight electrical fires because such fires are a real possibility due to the conversion of electricity and other energy forms to heat as electronic equipment operates. Not only can overheating lead to fires, but it can also cause damage to both the overheated component and other components surrounding it. To reduce the risk of fires and other damage from overheating, many pieces of electronic equipment are equipped with protective devices. The most common type of protective devices are fuses and circuit breakers. A fuse is simply a conductor that is installed in the circuit. However, the conductor in the fuse is designed to melt if the amperage in the circuit exceeds a certain level, above which components in the circuit are likely to overheat. Thus, once a fuse "blows," it is not reusable. Circuit breakers are devices of various designs that also contain a conductor to complete a circuit. But circuit breakers also contain a thermal element that reacts to heat by breaking the circuit once a certain temperature is reached. Thus, most circuit breakers are resettable once the circuit temperature drops below the actuation temperature. Additionally, most circuit breakers can be manually "popped" and reset.

Because protective devices work by interrupting circuits, they can be the reason a device is inoperative and, therefore, should be checked when troubleshooting circuits. A protective device may be defective because it does not provide continuity or because it does not respond correctly to overheat conditions correctly. In this job sheet, you will learn how to test protective devices for continuity. Job Sheet 16 deals with testing sensor devices for proper response to environmental conditions.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Multimeter or continuity light
- Fuses and circuit breakers provided by your instructor
- Test leads
- Paper and pencil

Job Sheet 13

B. Procedure

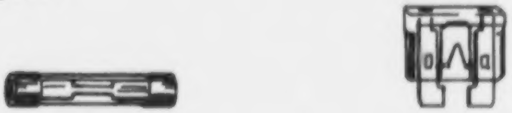
☐ 1. Select the device to be tested.

Note: In actual practice, fuses are installed in several ways. Many fuses snap into metal clamps that serve both as terminals and as holders. Fuses for electronic devices are sometimes soldered in place. Some electronic devices have fuses in holes with caps that must be removed to access the fuse. Other fuses plug into fuse blocks. In the first two types of installation, the fuse can normally be tested in place with power removed from the equipment.

☐ 2. Identify the leads on the device.

Note: The two most common fuse designs used with commercial electronics are the cartridge and blade designs shown in Figure 1. The cartridge type is often referred to as a *wire fuse* or *strip fuse* based on the type of conductor used in the fuse. In both types of fuses, it is often possible to tell whether the fuse has blown just by visually examining it. But when testing is to be used, the leads of the cartridge fuse are the two metal end caps, while the leads of the blade fuse are the two metal pieces extending from the plastic body. Because most circuit breakers have terminals for connecting wires, these serve as the leads for such devices.

Figure 1



Cartridge Blade

☐ 3. If testing a circuit breaker, verify that it is reset or in a closed position.

☐ 4. With the multimeter set to measure resistance, touch one probe of the multimeter or continuity light to one of the fuse leads or circuit breaker terminals.

☐ 5. Touch the other probe to the other lead or terminal.

☐ 6. Check the multimeter reading or continuity light illumination.

☐ 7. If the multimeter reading is ∞ or if the continuity light does not illuminate, reject the device and go to Step 13.

☐ 8. If the multimeter reading is 0 or if the continuity light is on, go to Step 9 if testing a circuit breaker or accept the fuse and go to Step 13 if testing a fuse.

Job Sheet 13

☐ 9. Open the circuit breaker or switch it to *off*.

☐ 10. Repeat Steps 4-6.

☐ 11. If the multimeter reading is 0 or if the continuity light illuminates, reject the device and go to Step 13.

☐ 12. If the multimeter reading is ∞ or if the continuity light is off, accept the device and go to Step 13.

☐ 13. Record your results.

☐ 14. Repeat Steps 1-13 as applicable for the next device.

☐ 15. Return equipment and materials to their proper storage location.

Evaluator's comments:____

DC and DC Circuits
Unit 4

Job Sheet 14— Test and Replace Capacitors

Name ______________________ Attempt Number ____________

Date ______________________ Overall Rating ____________

Evaluation criteria	Rating
• Procedure was done correctly	________
• Equipment was used correctly	________
• Capacitor status was correctly identified	________

Introduction: There are basically three electrical problems that can occur internal to a capacitor:

- the capacitor can be shorted
- the capacitor can be open
- the capacitor can be leaking

Each of these conditions can be revealed by checking the capacitor with an ohmmeter or multimeter set up as an ohmmeter. When touched to the leads of the capacitor, the ohmmeter will send current through the capacitor. A functioning capacitor will build up a charge as the current goes through it. This is indicated by a change in the ohmmeter reading as it increases toward ∞ as the capacitor becomes fully charged. However, if the capacitor is shorted, current flows but does not build up a charge on the capacitor plates. This is indicated by a 0 or low resistance reading on the ohmmeter. If there is an open condition in the capacitor, current will not flow through it, resulting in an immediate ∞ reading. Finally, if the capacitor is leaking, the charge build-up will be slower and will probably never allow the ohmmeter to reach ∞.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Note: Prior to performing this procedure, ensure that your instructor has demonstrated the ohmmeter response of a known-good capacitor. If not already done, ask your instructor to demonstrate the response before beginning this procedure.

A. Equipment and materials

- Ohmmeter or multimeter
- Test leads
- Capacitors supplied by your instructor
- Paper and pencil

Job Sheet 14

B. Procedure

☐ 1. Select the capacitor to be tested.

☐ 2. With the multimeter set to measure resistance, touch one probe of the multimeter to one of the capacitor leads.

☐ 3. Touch the other probe to the other lead.

☐ 4. Check the multimeter and observe the reading and behavior of the needle.

☐ 5. Continue to monitor the meter until the reading is 0, ∞, or there is no longer any needle movement toward ∞.

☐ 6. Classify the capacitor as good, shorted, open, or leaking and record your results.

☐ 7. Repeat Steps 1-6 for the remaining capacitors.

☐ 8. Return equipment and materials to their proper storage location.

Evaluator's comments:____

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DC and DC Circuits
Unit 4

Job Sheet 15— Test and Replace Coils

Name ______________________________ Attempt Number ____________

Date ______________________________ Overall Rating ____________

Evaluation criteria	Rating
• Procedure was done correctly	________
• Equipment was used correctly	________
• Coil status was correctly identified	________

Introduction: Coils are tested using an inductance meter. The exact method depends on the type of inductance meter used and the coil being tested. For this procedure you will largely rely on the procedure defined by the operator's manual for the inductance tester. In addition to the inductance test, these instructions may include procedures for ringing tests, continuity checks, and other tests. Discuss these procedures with your instructor and the relative time and costs involved as compared to simply replacing a suspect coil with a known good coil. Unless the coil is extremely expensive or hard to obtain or unless a facility is set up to do inductance testing, actual component testing may not be done.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Inductance meter
- Operator's manual provided with inductance meter
- Coils provided by your instructor
- Paper and pencil

B. Procedure

☐ 1. Select the coil to be tested.

☐ 2. Attach the inductance meter to the coil.

☐ 3. Observe and record the inductance value.

☐ 4. Compare the measured value to the rated value.

☐ 5. If the measured value is not within specifications, reject the coil and go to Step 9; otherwise, continue the procedure.

☐ 6. Conduct other tests defined by the inductance tester operator's manual.

☐ 7. Compare the test results to the specified performance.

☐ 8. If the test results are not acceptable, reject the coil; if the test results are acceptable, accept the coil.

☐ 9. Repeat Steps 1-8 as applicable for remaining coils.

☐ 10. Return equipment and materials to their proper storage location.

Evaluator's comments:____

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DC and DC Circuits
Unit 4

Job Sheet 16—Test and Replace Sensor Devices

Name	____________________	Attempt Number	__________
Date	____________________	Overall Rating	__________

Evaluation criteria	**Rating**
• Procedure was done correctly	________
• Equipment was used correctly	________
• Sensor status was correctly identified	________

Introduction: Electronic equipment frequently serves as sensors or contains sensors. Sensors are devices that respond to changes in their environment. These changes may be temperature, light, pressure, vibration, sound, or virtually any other stimulus. Often, sensors are combined with other electronic devices to provide application of the sensor devices. For example, a thermistor is a resistor that changes in resistance value as temperature changes. A thermostat is a switch that is opened and closed in response to changes in temperature. A photoelectric relay opens and closes in response to exposure to light. Consequently, there are often two aspects of a sensor device to check. First, does the device react to changes in the intended stimulus? Secondly, does the reaction to changes in stimulus produce the expected change in signal or circuit characteristics? For example, does the thermistor's resistance value change? In this job sheet, you will verify the environmental and electrical responses of various types of sensor devices. In some cases, the tests described are representative of the type of testing done and may not reflect a valid analysis of specific devices, which may require specialized test equipment and procedures. However, the procedures are useful in the troubleshooting process and may be capable of determining whether a specific device is a possible source of a problem.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Multimeter
- Sensor devices provided by your instructor
- Test leads
- Paper and pencil
- Equipment necessary to produce stimulus changes (heat source, lights, etc.)

Job Sheet 16

B. Procedure

☐ 1. Select the device to be tested.

☐ 2. Determine the electrical characteristics and specifications of the device.

☐ 3. Determine the environmental responses and parameters for those responses for the device.

☐ 4. Design a test that will verify the electrical operation of the device.

☐ 5. Design a test that will verify the environmental responses of the device.

Note: For example, your test of a thermistor may call for it to be hooked up to the multimeter in set to measure resistance. After measuring the resistance of the thermistor, your test may call for heat to be applied from a heat gun and cooling air to be added from a can of compressed air while the multimeter is monitored for changes in resistance.

☐ 6. Discuss your test plan with your instructor.

☐ 7. Conduct the approved test to verify operation of the device.

☐ 8. Report test results to your instructor.

☐ 9. Repeat Steps 1-8 for other types of sensors.

☐ 10. Return equipment and materials to their proper storage location.

Evaluator's comments:____

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DC and DC Circuits
Unit 4

Job Sheet 17—Test and Replace Relays

Name ______________________ Attempt Number __________

Date ______________________ Overall Rating __________

Evaluation criteria	**Rating**
• Procedure was done correctly	__________
• Equipment was used correctly	__________
• Relay status was correctly identified	__________

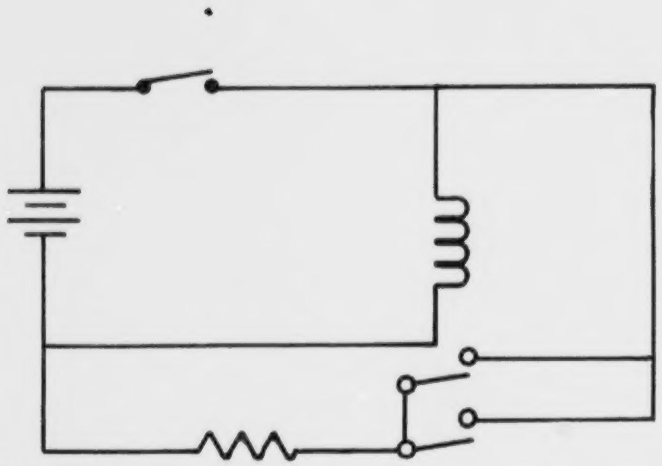
Introduction: Relays are special switching devices that can be made to respond automatically to changes in signals and electrical values. For this reason, they are useful devices in electronic equipment. If a relay reacts correctly to its inputs, then it is probably functioning properly. Testing a relay involves exercising it to ensure that it does respond correctly to inputs.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Multimeter
- DPST relay
- SPST switch
- Power supply
- 10 Kohm resistor
- Test leads
- Low-voltage conductor
- Mounting surface and hardware
- Pencil and paper
- Circuit drawing

Job Sheet 17



B. Procedure

☐ 1. Assemble circuit per drawing, but do **not** apply power.

Note: Leave the SPST switch open and the power supply set to 0.

☐ 2. Have your instructor check your circuit and prescribe a voltage setting for the power supply.

☐ 3. Set the power supply to the setting recommended by your instructor and apply power to the circuit.

☐ 4. Set the multimeter to measure voltage.

☐ 5. Measure voltage across one set of relay terminals and record your reading.

☐ 6. Close the SPST switch.

☐ 7. Measure voltage across the same set of relay terminals and record your reading.

☐ 8. Repeat Steps 5-7 for each set of relay terminals.

☐ 9. Remove power from the circuit.

☐ 10. Compare the voltage readings to the expected readings for the relay.

☐ 11. Accept or reject the relay based on whether the contact values are acceptable.

☐ 12. Disassemble the circuit and return equipment and materials to their proper storage location.

Job Sheet 17

Evaluator's comments:____

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DC and DC Circuits
Unit 4

Job Sheet 18—Test and Replace Solenoids

Name ______________________________ Attempt Number ____________

Date ______________________________ Overall Rating ____________

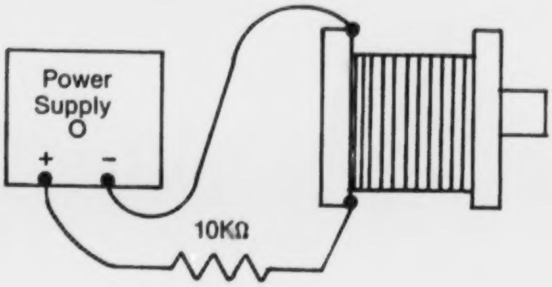
Evaluation criteria	**Rating**
• Procedure was done correctly	________
• Equipment was used correctly	________
• Solenoid status was correctly identified	________

Introduction: Solenoids are useful devices in electronic equipment because they can use changes in voltage to produce mechanical movement. The electromagnetic field induced in the solenoid creates movement of a shaft which can be attached to other circuit devices for use as a switch, control, or other device where movement in response to voltage changes can be put to work. If the source of an equipment failure is suspected to be a solenoid, the simple test described in this job sheet will help verify whether or not the solenoid is working.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Multimeter
- Solenoid
- Power supply
- 10 Kohm resistor
- Low-voltage conductor
- Test leads
- Circuit drawing



Job Sheet 18

B. Procedure

☐ 1. With the multimeter set to measure resistance, determine the ohms value across the solenoid coil.

☐ 2. Energize the power supply.

☐ 3. With the multimeter set to measure voltage, measure the voltage of the power supply and adjust it to 0 volts.

☐ 4. Turn off the power supply.

☐ 5. Assemble circuit per drawing, but do **not** apply power.

☐ 6. Energize the circuit.

☐ 7. Adjust the voltage of the power supply up and down and observe the solenoid shaft for movement.

☐ 8. If the solenoid shaft does not move smoothly in response to the adjustments of the power supply, reject the solenoid.

☐ 9. Turn off power to the circuit.

☐ 10. Disassemble circuit and return equipment and materials to their proper storage location.

Evaluator's comments: ____________________

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DC and DC Circuits
Unit 4

Job Sheet 19—Troubleshoot DC Circuits

Name ______________________ Attempt Number __________

Date ______________________ Overall Rating __________

Evaluation criteria	Rating
• Troubleshooting procedure was well designed	______
• Equipment was used correctly	______
• Correct problems were identified	______
• Problems were correctly repaired	______

Introduction: For this job sheet, your instructor will provide you with a DC circuit that has one or more problems. Those problems may be defective components, shorts, opens, incorrect wiring, and other problems that an electronics technician is likely to encounter in this type of circuit. Using what you have learned about troubleshooting, component testing, and DC circuit operation, you will be required to design a troubleshooting procedure for the circuit and then carry out that procedure to identify and correct problems in the circuit.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- DC circuit or device provided by instructor
- Paper and pencil
- Equipment as required by troubleshooting procedure
- Materials as required by troubleshooting procedure

B. Procedure

☐ 1. Examine device for preliminary troubleshooting assessment.

☐ 2. Define troubleshooting procedure in writing.

☐ 3. Discuss troubleshooting procedure with instructor.

☐ 4. Conduct troubleshooting procedure.

Job Sheet 19

☐ 5. Identify problems and record results of troubleshooting.

☐ 6. Repair equipment to return to operational state.

☐ 7. Verify that repair has returned equipment to an operational state.

☐ 8. Discuss the problem and your response with your instructor.

☐ 9. Return equipment and materials to their proper storage location.

Evaluator's comments:____

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AC and AC Circuits
Unit 5

Objective Sheet

Unit Objective

After completing this unit, the student should be able to discuss the use of alternating current and the operation of AC circuits in electronic applications and be able to build and test AC circuits. The student should demonstrate these competencies by completing the assignment sheets and job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms associated with AC and AC circuits to their correct definitions.
2. Explain the role of alternating current in the operation of electronic equipment.
3. Describe methods for providing safety grounding for AC circuits.
4. Match characteristics of an AC waveform to their correct descriptions.
5. Distinguish between sinusoidal and nonsinusoidal waveforms.
6. Describe AC waveform phase relationships.
7. Match various types of circuits to correct descriptions of their phase angles.
8. Complete statements regarding inductance.
9. Describe the process of self-induction.
10. Describe the relationship between current and voltage in an inductive AC circuit.
11. Describe power in an inductive circuit.
12. Complete statements about the operation of a generator.
13. Complete statements about the operation of an AC motor.
14. Select from a list roles of transformers in the operation of electronic equipment.
15. Match types of transformers to their correct descriptions.

Objective Sheet

16. Identify types of three-phase circuits.
17. Identify types of single-phase transformer connections.
18. Select true statements about the time constant of inductive circuits.
19. Complete statements about inductive reactance.
20. Describe the process of mutual induction.
21. List factors that influence the strength of inductors.
22. Complete statements regarding the quality of inductors.
23. State formulas for connecting inductors in series and parallel.
24. Complete statements regarding the relationship between current and voltage in an RL circuit.
25. Describe impedance in RL circuits.
26. State the formula for determining phase shift in RL circuits.
27. Complete statements regarding capacitance.
28. List factors that influence the capacitance of a capacitor.
29. Name ways of classifying capacitors.
30. Select from a list uses of capacitors in electronic circuits to their correct descriptions.
31. Match capacitor defects to their correct descriptions.
32. State rules for connecting capacitors in series and parallel.
33. Complete statements regarding time constants in an RC circuit.
34. Complete statements regarding the relationship between current and voltage in an RC circuit.
35. Describe power in an RC circuit.
36. Describe impedance in RC circuits.
37. State the formula for determining phase shift in RC circuits.

Objective Sheet

38. Complete statements regarding capacitive reactance.

39. State formulas used to determine the characteristics of series RC circuits.

40. State formulas used to determine the characteristics of parallel RC circuits.

41. Select from a list uses of capacitive circuits.

42. Complete statements regarding the characteristics of series RCL circuits.

43. Describe the resonant characteristics of a series RCL circuit.

44. Complete statements regarding the characteristics of parallel RCL circuits.

45. Describe the resonant characteristics of a parallel RCL circuit.

46. Match processes for conditioning signals to their correct descriptions.

47. List devices and circuits involved in analog signal conditioning.

48. Match devices and circuits involved in digital signal conditioning to their correct descriptions.

49. Select from a list correct statements about AC differentiator and integrator circuits.

50. Identify configurations of filter circuits.

51. Match the operation of types of filter circuits to their correct descriptions.

52. Distinguish between the operation of a high-pass filter and a low-pass filter.

53. State guidelines for impedance matching.

54. Complete statements regarding rectangular notation.

55. Complete statements regarding polar notation.

56. Determine sine wave conversions. (Assignment Sheet 1)

57. Compute period. (Assignment Sheet 2)

58. Determine current flow direction. (Assignment Sheet 3)

59. Solve for total inductance. (Assignment Sheet 4)

Objective Sheet

60. Compute inductive reactance. (Assignment Sheet 5)

61. Compute applied voltage and impedance of RL circuits. (Assignment Sheet 6)

62. Compute inductor quality. (Assignment Sheet 7)

63. Solve time constant problems. (Assignment Sheet 8)

64. Compute capacitance values. (Assignment Sheet 9)

65. Compute RC time constants. (Assignment Sheet 10)

66. Compute capacitive reactance. (Assignment Sheet 11)

67. Determine phase relationships in RC circuits. (Assignment Sheet 12)

68. Compute values of RC circuits. (Assignment Sheet 13)

69. Solve for reactance. (Assignment Sheet 14)

70. Solve for impedance. (Assignment Sheet 15)

71. Solve for parameters of resonant circuits. (Assignment Sheet 16)

72. Solve problems related to parallel RCL circuits. (Assignment Sheet 17)

73. Analyze a parallel resonant circuit. (Assignment Sheet 18)

74. Calculate the power in three-phase circuits. (Assignment Sheet 19)

75. Determine three-phase transformer connections. (Assignment Sheet 20)

76. Measure AC voltages using a multimeter. (Job Sheet 1)

77. Measure AC current using a multimeter. (Job Sheet 2)

78. Determine the configuration of a multiple-winding transformer. (Job Sheet 3)

79. Test and replace a transformer. (Job Sheet 4)

80. Show the effect of inductance in AC circuits. (Job Sheet 5)

81. Solve for values of an operating RL circuit. (Job Sheet 6)

82. Test capacitors with an ohmmeter. (Job Sheet 7)

Objective Sheet

83. Determine the effect of AC and DC on capacitors. (Job Sheet 8)

84. Determine time constants of RC circuits. (Job Sheet 9)

85. Construct a neon bulb flasher. (Job Sheet 10)

86. Show the effect of capacitive reactance in AC circuits. (Job Sheet 11)

87. Determine capacitive reactance and impedance in RC circuits. (Job Sheet 12)

88. Determine resonance in a series RCL circuit. (Job Sheet 13)

89. Determine the resonant frequency of an RCL parallel circuit. (Job Sheet 14)

90. Troubleshoot AC circuits. (Job Sheet 15)

AC and AC Circuits
Unit 5

Information Sheet

1. Terms and definitions

a. **Bandwidth**—A signal frequency or a range of frequencies over which a device or circuit transmits AC energy with no significant loss

b. **Coupling**—Linking of two or more circuits or devices by electrostatic lines of force (capacitive coupling), electromagnetic lines of force (inductive coupling), or direct connection (direct coupling) to allow energy to be transferred between the circuits or devices

c. **Dielectric**—Material that is a nonconductor of electricity

d. **Function**—A value that is related to a second value so that their relationship can be described mathematically such that if one value is known the other can be determined

e. **Impedance matching**—Design of circuits so that their impedances are equal or can be adjusted to be equal to each other

f. **Instantaneous value**—The value of a quantity that varies over time at a specified point in time

g. **Lag**—Extent to which one AC characteristic follows another in time

h. **Lead**—Extent to which one AC characteristic precedes another in time

i. **Linear**—Relationship between variables in which the relationship remains constant so that a graph of their variation produces a straight line

j. **Phase angle**—Measure of the difference of the identical positions of two characteristics of AC power

Note: Phase angles are normally measured at maximum values and may compare current and voltage in a single alternation or compare current to current or voltage to voltage in successive cycles. Phase angle is normally measured in degrees or radians, with one cycle being 360° or 2π radians.

k. **Phase shift**—Condition in which the phase angle of two AC characteristics is other than 0° or the act of causing the phase angle of two AC characteristics to change

l. **Propagation**—Transmission of energy

Information Sheet

m. **Resonance**—Condition in which complementary characteristics, such as inductance and capacitance, of an AC circuit are equal

n. **Root mean square (rms)**—Term applied to voltage or current to indicate effective voltage or current, being descriptive of the mathematical relationship between effective voltage and effective current and the average of all instantaneous values of a waveform

o. **Sinusoidal**—Having the shape and properties of a sine curve; that is, a curve in which the ratio of the y-value to the x-value can be described by the sine of a triangle defined by the curve

p. **Tank circuit**—A parallel resistive-capacitive-inductive circuit in which the inductive and capacitive values are equal

Note: Tank circuits are also referred to as *parallel-resonant* or *anti-resonant* circuits.

q. **Time constant**—Numerical value that represents that steady rate of change of a variable over time

r. **Vector**—Method of representing a value to show that it has both direction and quantity and that can be mathematically combined (added, subtracted, etc.) with another such value to determine the net result

2. **The role of alternating current in the operation of electronic equipment**—Because the operation of electronic equipment requires the use of motors, lamps, speakers, displays, and other devices that function more efficiently when powered by alternating current and because of the availability of alternating current, most electronic equipment uses alternating current to power AC devices and rectifies alternating current to provide required DC power.

3. **Methods for providing safety grounding for AC circuits**

a. Neutral ground—Use of a third wire in a power cord and power line that connects to ground

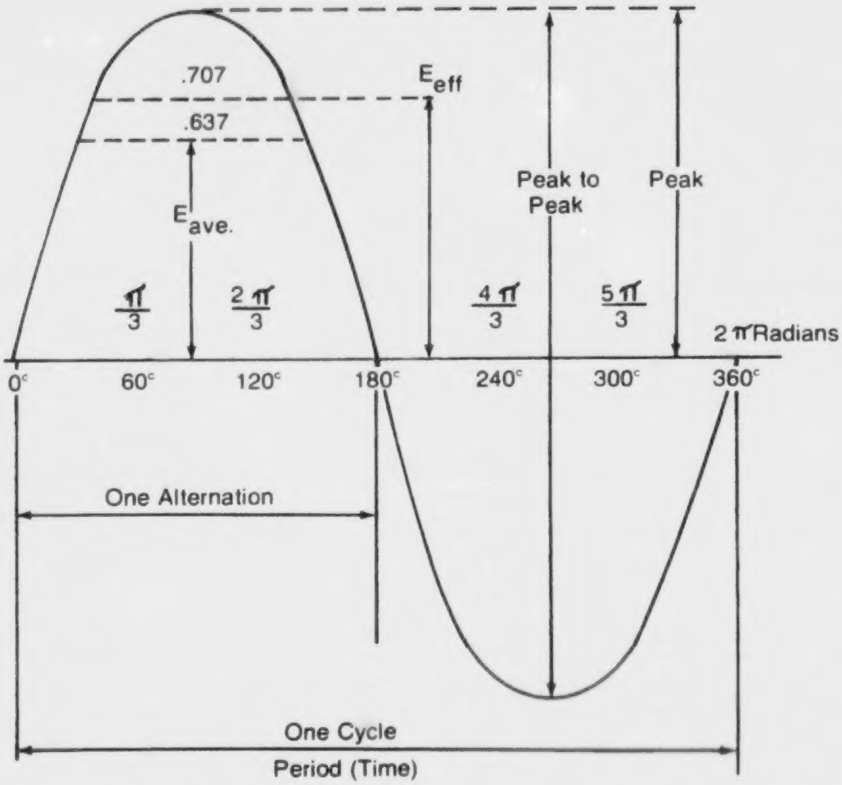
b. Isolation transformer—Device that provides power to equipment while also interrupting the equipment's direct connection to the power line

c. Polarized plug—Equipment power plug built so that it can only be inserted into an outlet in one way

Information Sheet

4. Characteristics of an AC waveform

Example:


.707
.637
E eff
E ave.
Peak to Peak
Peak
π/3
2π/3
4π/3
5π/3
2π Radians
0°
60°
120°
180°
240°
300°
360°
One Alternation
One Cycle
Period (Time)

a. Shape—Form taken by the displayed waveform

Examples: Rectangular, square, sine

Note: AC waveforms are normally displayed as *sinusoidal waves* or *sine waves*. A sine wave is a representation of the energy available in an electrical current. This energy varies with time so that the value for any given moment is referred to as *instantaneous value.* A sine wave is a representation of the infinite number of instantaneous values in an alternating waveform over a period of time. Because electron flow in AC constantly reverses direction, the representative wave is a curve that rises above and falls below a midpoint value.

b. Amplitude—Height of the waveform across a full cycle

c. Percent amplitude—A portion of the height of a waveform as measured at various points in the waveform

Information Sheet

d. Cycle—One full set of values for a repetitive waveform as measured from one point on a waveform to the corresponding point on the next waveform

e. Alternation—One half of a cycle

Note: An AC cycle consists of a negative alternation and a positive alternation.

f. Leading edge—Portion of the waveform showing increasing amplitude

g. Trailing edge—Portion of the waveform showing decreasing amplitude

h. Peak—Height of one alternation

i. Peak-to-peak—Wave amplitude as the combined height of both alternations

j. Period—Time required to complete one cycle

k. Frequency—Number of cycles completed in one second

l. Rise time—Time required for the waveform to build from 10 percent of amplitude to 90 percent of amplitude

m. Fall time—Time required for the waveform to drop from 90 percent of amplitude to 10 percent of amplitude

n. Average voltage—Mean electrical potential of an alternation, mathematically defined as 0.636 times the alternation's peak value

o. Effective voltage—AC alternation value that will produce the same amount of heat energy in a resistance as a DC value, mathematically defined as 0.707 times the alternation's peak value

Note: Because of its mathematical relationship to average and peak voltage, effective voltage is often referred to as *root mean square voltage* or simply *rms.*

5. **Sinusoidal and nonsinusoidal waveforms**

a. Sinusoidal waveform—Periodic wave whose amplitude is a function of the sine of a linear quantity such as phase or time

Note: A sinusoidal wave or *sine wave* is a smooth curve that can be represented by the trigonometric function $y = \sin x$, where y is the amplitude and x is a linearly changing value. These values can be plotted on an x-y coordinate graph, giving a wave representation. AC alternations can be plotted as sinusoidal waves. Sine waves exhibit smooth curves and are symmetrical along a vertical line drawn through their peak.

Information Sheet

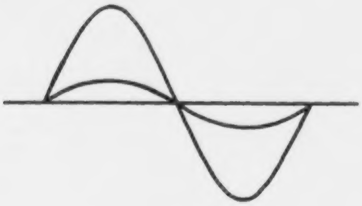
b. Nonsinusoidal waveform—Periodic wave that does not exhibit a constant functional relationship between its amplitude and any linear value associated with the propagation of the wave or whose functional relationship is other than a sine relationship

Examples: Sawtooth, square, triangular, cosine

6. AC waveform phase relationships

a. In-phase—Condition in which the maximum displacements of two waveforms occur at the same time

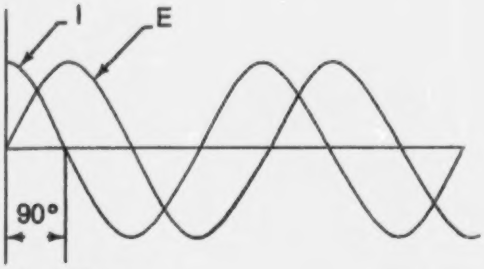
Example:



In-Phase Relationship

b. Out-of-phase—Condition in which maximum displacement of a second waveform occurs after the maximum displacement of another waveform

Example:



90° Out-of-Phase

Note: Like a circle, an AC cycle is considered to consist of 360 degrees. Two waveforms can be a fraction of a degree out of phase to as much as 359+ degrees out of phase. The example shown above illustrates two waveforms that are 90° out of phase, or one-fourth of a cycle. Similarly, a one-half cycle difference would be 180° out of phase, while a three-fourths cycle difference would be 270° out of phase.

Information Sheet

7. **Phase angles for various types of circuits**

    a. Purely resistive circuit—Has a phase angle of 0°

    b. Purely capacitive circuit—Current leads voltage by a phase angle of 90°

    c. Purely inductive circuit—Voltage leads current by a phase angle of 90°

8. **Statements regarding inductance**

    a. Inductance is the physical property of a component or circuit that opposes any change in the current present in that component or circuit.

    b. As a result of inductance, when the current in a conductor is changed, EMF is induced.

    c. The symbol for inductance is L.

    d. The unit of measurement for inductance is the Henry (H).

    Note: Because one Henry greatly exceeds the inductance normally found in electronic circuits, in practice inductance is usually expressed as millihenries (mH) or microhenries (µH).

9. **Process of self-induction**

    a. When current flows in an inductor, a magnetic field is produced that moves with the current.

    b. The movement of the magnetic field induces a voltage back into the wire counter to the original current that is called *counter EMF*.

    c. Self-induction occurs when the current increases or decreases.

    d. Counter EMF opposes changes in current flow.

10. **The relationship between current and voltage in an inductive AC circuit**

    a. When an AC voltage is applied to an inductor, a magnetic field is produced that induces an AC voltage that is 180° out of phase with the applied voltage.

    b. The waveform of the induced voltage has the same characteristics as the applied voltage wave form.

    c. The counter EMF of the circuit will be 90° out of phase with the induced current.

Information Sheet

d. The current flowing in an inductive circuit is directly proportional to the applied voltage.

e. The current flowing in an inductive circuit is inversely proportional to the inductive reactance of the circuit.

f. The formula for calculating current in an inductive circuit is

$$I = \frac{E}{X_L}\text{, where } X_L \text{ is the inductive reactance}$$

11. Power in an inductive circuit

a. With pure inductance, no power is dissipated; however, due to conductor resistances and other values that prevent the construction of pure inductors, power dissipation occurs in actual inductive circuits.

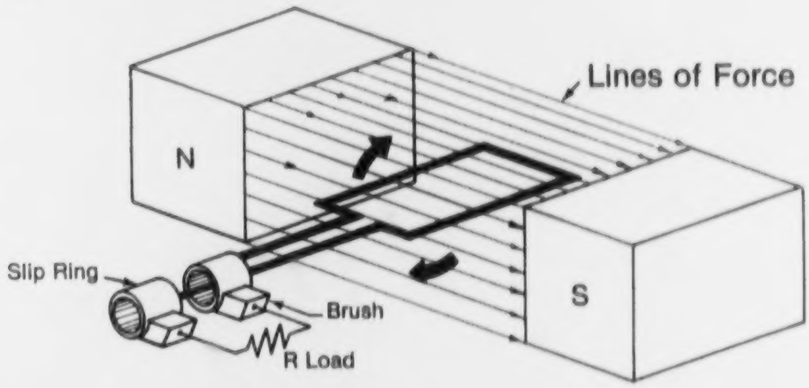
b. Because power is dissipated in the resistances, standard power dissipation formulas can be used for inductive circuits.

Examples: $P = EI$, $P = I^2R$, and $P = \frac{E^2}{R}$

12. Operation of a generator

Note: Generators come in a variety of designs and can be constructed to produce either AC or DC output. The illustration below shows a simplified typical AC generator. In some generators, the armature (*stator*) remains stationary, and the magnetic field structure (*rotor*) rotates.

Example:



a. A conductive loop called an *armature* rotates within a magnetic field.

b. The rotation of the armature induces electrical flow in the loop.

c. Electrical current is carried to one of the slip rings connected to each end of the armature.

d. The slip ring is in contact with a conductive brush that is connected to the load circuit.

e. Electricity flows into the load circuit to provide power to the load.

f. Electrical flow continues through the load circuit to the other slip ring and back into the armature.

g. As the armature continues to rotate, the direction of electrical flow and the amount of induced current varies.

h. When the armature is parallel to the magnetic field, there is no electrical flow; once the armature moves past parallel, the current flow reverses direction.

i. If the number of armature coils and the number of sets of magnets are the same, the electricity produced will all be of the same phase and the generator is called a *single-phase* generator.

j. Many AC generators use three armature coils for each set of magnets, resulting in the production of *three-phase power*.

13. Operation of an AC motor

a. The motor contains a field structure that provides a constant magnetic field within the motor housing.

b. A rotating armature is positioned within the magnetic field, consisting of a conductive loop.

c. When electricity is applied to the armature, the loop becomes an electromagnet.

d. The north pole of the armature and the north pole of the field structure repel each other, as do the south poles, causing the armature to rotate.

e. When the AC electricity alternates, the polarity of the armature changes so that the like poles again repel reach other, causing the armature to continue to rotate as long as power is applied.

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f. The armature is connected to a shaft that is used to transfer mechanical power to perform work.

14. The role of transformers in the operation of electronic equipment

Note: Transformers are widely used in distribution of AC power to increase (step-up transformer) or decrease (step-down transformer) voltage and current and to boost voltage (booster transformer) to allow distribution over a long distance. However, transformers are also frequently used in electronic equipment to serve a variety of functions.

a. Voltage reduction

Note: The amount of reduction is determined by the ratio of the primary turns to the secondary turns. For example, if 100 volts are applied to a transformer with 200 turns on the primary coil and 50 turns on the secondary coil, the reduction will be a 4:1 ratio or an output of 25 volts.

b. Current reduction

Note: Current reduction is also dependent on the ratio of the primary and secondary turns as is the case with voltage.

c. Circuit isolation

d. Circuit coupling

15. Types of transformers

Note: Transformers may be classified in a number of ways, such as their function, their core construction, whether they can be varied, the configuration of their windings, etc. In addition to the functions discussed in the previous objective, the following classifications are often applied transformers used with electronic equipment.

a. By core construction

- Air-core—Transformer without a metal core, generally used in low-power, high-frequency applications
- Iron-core (metal-core)—Transformer with a metal core (often laminated iron or steel), generally used in high-power, low-frequency applications
- Toroidal core—Transformer with a ring-shaped core

b. By winding configuration

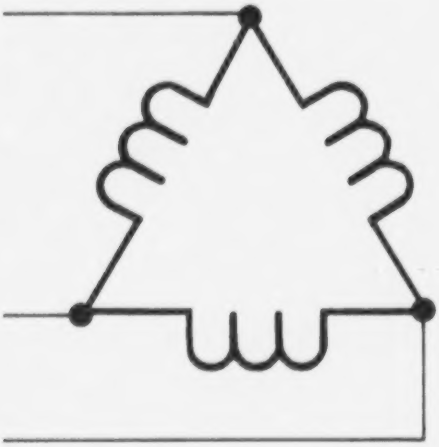
- Autotransformer—Transformer whose primary and secondary windings use a common core and are physically connected

16. Types of three-phase circuits

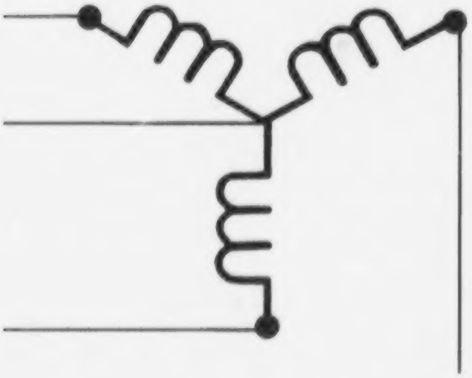
Note: Most AC power in North America uses three phases—that is, the generators output three currents that are 120° out of phase with each other. Consequently, two of the most common winding configurations for AC transformers are the wye and delta designs.

a. Delta—Voltage across each load member is the full-line voltage; amperage in each load member is 1.732 x line amperage

Note: The constant 1.732 is the square root of 3.



b. Wye—Amperage in each load member is the full-line amperage; voltage across each member is 1.732 x line voltage



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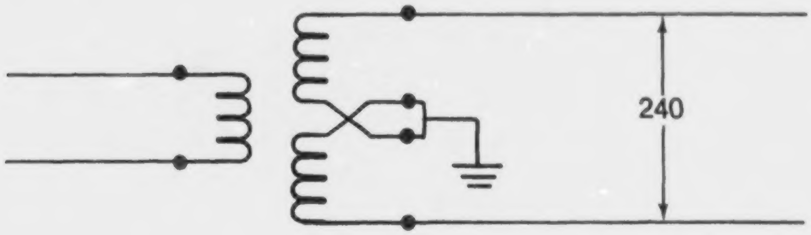
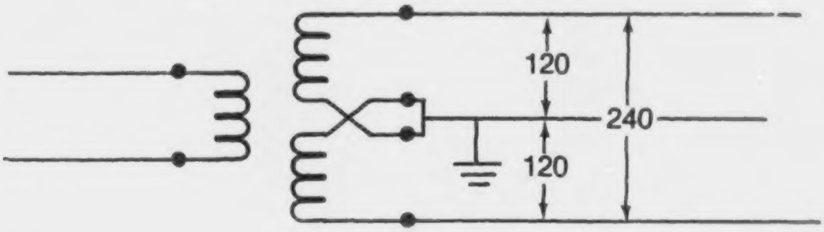
17. Types of single-phase transformer connections

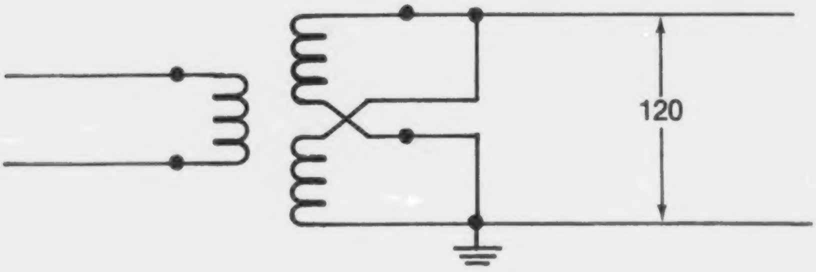
a. 240 volts, two-wire



b. 120/240 volts, three-wire



c. 120 volts, two-wire



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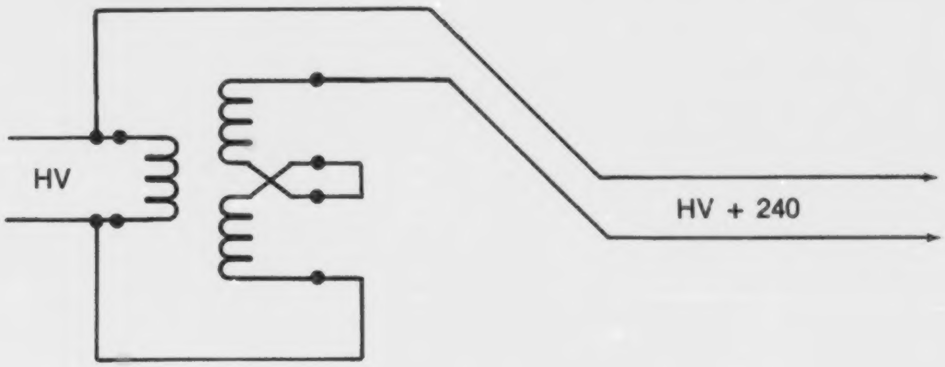
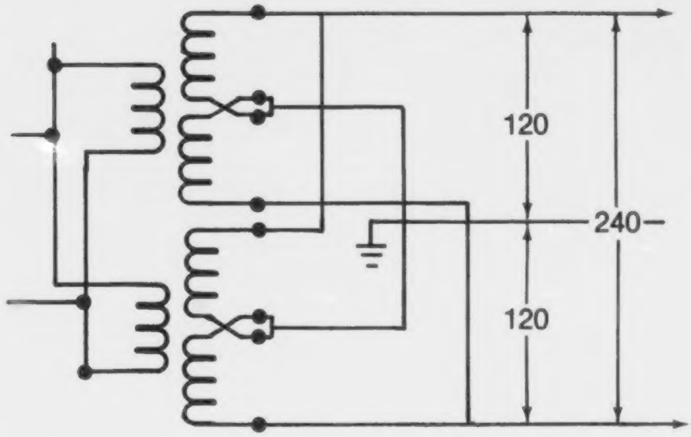
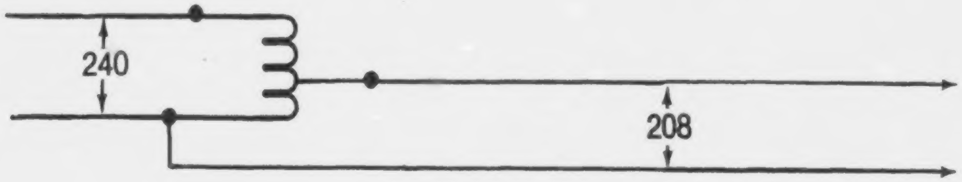
d. High-voltage, boosted by 240 volts



e. 120/240 volts, three-wire with additional power capacity of two transformers



f. 208 volts, two-wire from 240-volt through autotransformer



Information Sheet

18. Time constant of inductive circuits

a. The time constant for inductive circuits represents the time required for the current to change (increase or decrease) by 63.2 percent.

b. The time constant is a function of the inductance and the resistance in the circuit.

c. The formula for the time constant is

$$T = \frac{L}{R}$$

d. It takes five time constant intervals for current to rise from zero to its maximum or to fall from its maximum to zero for any given inductance value.

19. Inductive reactance

a. Inductive reactance is the opposition to AC.

b. Inductive reactance is directly proportional to the inductance of the applied voltage.

c. Inductive reactance is directly proportional to the frequency of the current.

Note: As the frequency of the AC increases, inductive reactance increases.

d. Inductive reactance is represented by the symbol X_L.

e. The unit of measure for inductive reactance is the ohm.

f. Inductive reactance can be calculated by the formula

$$X_L = 2\pi fL$$

20. Process of mutual induction

a. Mutual induction is the process by which one current carrying conductor causes a voltage to be induced in another conductor.

b. The amount of mutual inductance between adjacent conductors depends on the degree of coupling between the conductors.

Note: The coefficient of coupling is represented by the symbol K, where a K of 1 indicates 100 percent coupling.

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c. The amount of mutual inductance between adjacent conductors depends on the inductance value of each conductor.

d. The symbol for mutual induction is L_M.

Note: The formula for calculating mutual induction is

$$L_M = K \sqrt{L_1 \times L_2}$$

e. The unit of measure for mutual induction is the Henry, where one Henry represents a condition in which a current change of one ampere per second will induce a voltage of one volt in the other conductor.

21. Factors that influence the strength of inductors

a. The number of turns in the coil

Note: The strength of the inductor varies as a square of the number of coils.

b. The permeability of the core material

Note: The greater the permeability of the core, the greater the inductance.

c. The length of the coil

Note: The greater the length of the coil, the lower the inductance.

22. The quality of inductors

a. The quality of a coil is the ratio between the energy stored in the magnetic field of the coil as compared to the energy dissipated due to the resistance in the wire of the coil.

b. Because the energy of the coil's magnetic field is directly proportional to the inductive reactance of the coil, quality can also be viewed as a comparison of the coil's inductive reactance and the resistance in its wiring.

c. Inductor quality is represented by the letter Q.

d. Because inductor quality is a comparison of one resistance to another, there is no unit of measure.

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e. Inductor quality can be expressed in the formula

$$Q = \frac{X_L}{R}$$

f. Because induction quality is directly proportional to inductive reactance, increases in inductive reactance will result in improved inductor quality.

Example: An increase in the frequency of the inductor's AC will result in improved quality if there is not a corresponding proportional increase in resistance.

23. Formulas for connecting inductors in series and parallel

Note: Due to the resistance factor of inductors, the rules regarding their functioning in series and parallel circuits are similar to those for resistors.

a. For two or more inductors connected in series without mutual inductance, total inductance is equal to the sum of the individual inductances; $L_t = L_1 + L_2 + L_3$

b. For two or more inductors connected in series with mutual inductance in which the magnetic fields aid each other, total inductance is equal to the sum of the individual inductances plus two times the mutual inductance; $L_t = L_1 + L_2 + 2L_M$

c. For two or more inductors connected in series with mutual inductance in which the magnetic fields oppose each other, total inductance is equal to the sum of the individual inductances minus two times the mutual inductance; $L_t = L_1 + L_2 - 2L_M$

d. When two inductors are connected in parallel, the total induction may be calculated with the formula

$$L_t = \frac{L_1 \times L_2}{L_1 + L_2}$$

Note: The reciprocal formula used to find resistors in parallel may also be applied to inductors in parallel.

24. Relationship between current and voltage in an RL circuit

a. AC flow in an RL circuit causes voltage drops across the resistor and the inductor.

b. The voltage drop across the resistance can be found using Ohm's Law.

c. The voltage drop across the inductor can be found using Ohm's Law with X_L substituted for R.

d. The circuit current in an RL circuit lags the applied voltage by 90° and the voltage across the inductor leads the current by 90°.

e. The formula for applied voltage in a series RL circuit is

$$E_a = \sqrt{E_R^2 + E_L^2}$$

Note: The formula is derived by using vectors to solve the phase relationships of the voltages. By rearranging the formula, we can also solve for the resistance voltage or the inductor voltage:

$$E_R = \sqrt{E_a^2 - E_L^2} \qquad \text{or} \qquad E_L = \sqrt{E_a^2 - E_R^2}$$

25. Impedance in RL circuits

a. The total opposition to flow offered by both the resistor and the inductor is called impedance.

b. Impedance is expressed in ohms.

c. Impedance is represented by the symbol Z.

d. The formula to solve for impedance is a variation of Ohm's Law, where impedance replaces resistance:

$$Z = \frac{E_a}{I_t}$$

e. Another formula to determine impedance can be used if resistance and inductive reactance are known:

$$Z = \sqrt{R^2 + X_L^2}$$

Note: The variations on this formula are:

$$R = \sqrt{Z^2 - X_L^2} \qquad \text{or} \qquad X_L = \sqrt{Z^2 - R^2}$$

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26. Phase shift in RL circuits

a. Phase shift in an RL circuit is a function of the resistance and the inductive reactance.

b. The phase angle theta (θ) of an RL circuit may be found mathematically by the use of trigonometric formulas, such as:

$$\text{tangent } \theta = \frac{X_L}{R}$$

Note: The variations on this formula use the arc tangent, so that

$$\theta = \arctan\frac{X_L}{R} \quad \text{or} \quad \theta = \arctan\frac{E_L}{E_R}$$

27. Capacitance

a. Capacitance is the property of a device or circuit that allows it to store electrical energy as an electrostatic field.

b. The symbol for capacitance is C.

c. The unit of measure for capacitance is the farad (F).

d. One farad is equal to a capacitance such that one coulomb of charge is stored when one volt is applied.

Note: Because a coulomb is a very large charge, capacitance in electronics devices and circuits is generally expressed as microfarads (μF) and picofarads (pF).

e. Capacitance can be calculated with the formula:

$C = \frac{Q}{E}$, where Q is the quantity of charge and E is the applied voltage.

f. The principle device used to provide specific levels of capacitance in a circuit is called a capacitor and is able to discharge the collected electrons at a later time.

g. Capacitors are constructed of two metal plates separated by a dielectric.

28. Factors that influence the capacitance of a capacitor

a. The total area of the metal plates

b. The distance between the metal plates

c. The strength of the dielectric

Note: The dielectric strength of a material is often referred to as its *dielectric constant*.

29. Ways of classifying capacitors

a. Classified by adjustability

Examples: Fixed or variable

b. Classified by type of dielectric

Examples: Mica, ceramic, paper, mylar

c. Classified as electrolytic or nonelectrolytic

d. Classified by capacitance value

30. Uses of capacitors in electronic circuits

a. Coupling circuits

b. Storing charge

c. Releasing charge

d. Multiplying voltage

e. Filtering signals

31. Capacitor defects

a. Short—The dielectric is punctured or otherwise fails

b. Open—The leads become detached from the metal plates

c. Leakage—A resistive path forms in the dielectric

d. Value change—The rated capacitance value changes due to a manufacturing defect or abuse of the capacitor, such as excessive temperature or voltage

Information Sheet

32. Rules for connecting capacitors in series and parallel

a. When two or more capacitors are connected in series, the total capacitance is less than the capacitance of the smallest capacitor.

b. When two capacitors are connected in series network, the total capacitance may be calculated with the formula

$$C_t = \frac{C_1 \times C_2}{C_1 + C_2}$$

Note: The reciprocal formula used to find resistors in parallel may also be applied to capacitors in series.

c. The total capacitance of a parallel combination is always greater than the value of any capacitor in the parallel network.

d. When two or more capacitors connected in parallel, the total capacitance is the sum of the individual capacitors; $C_t = C_1 + C_2 + C_3$

33. Time constants in an RC circuit

a. A circuit that contains both resistive elements and capacitors is referred to as a resistive-capacitive (RC) circuit.

b. Capacitors charge and discharge at a time constant rate of 63.2 percent—that is, for each interval of time, the charge in the capacitor will increase by 63.2 percent of its remaining capacity or decrease by 63.2 percent of its existing charge.

c. Both the value of the capacitor and the value of resistance along the charge/discharge path affect the time interval constant required for a capacitor in a circuit to charge or discharge 63.2 percent.

d. The time interval in seconds required for a 63.2 percent increase or decrease in charge is

$T = R \times C$

e. It takes approximately five of the time constant intervals for a capacitor to fully charge or discharge.

34. Relationship between current and voltage in an RC circuit

a. When voltage is applied to an RC circuit, the voltage developed across the capacitor (E_C) is equal to and in phase with the applied voltage (E_a).

b. The sine wave current developed in the circuit will lead the E_a and E_C voltages by 90°.

c. When E_a and E_C are at their maximum values for their positive and negative alternations, current in the circuit is zero.

d. When E_a and E_C are at zero, current in the circuit is at its maximum.

e. The voltage drop across the resistor is in phase with the current in the circuit.

f. The voltage across the capacitor lags the current flowing in the circuit by 90°.

g. The formula for applied voltage in an RC circuit is

$$E_a = \sqrt{E_R^2 + E_C^2}$$

Note: The formula is derived by using vectors to solve the phase relationships of the voltages. By rearranging the formula, we can also solve for the resistance voltage or the capacitor voltage:

$$E_R = \sqrt{E_a^2 - E_C^2} \qquad \text{or} \qquad E_C = \sqrt{E_a^2 - E_R^2}$$

35. Power in an RC circuit

a. Power is actually only dissipated in the resistive portion of an RC circuit; however, power appears to be consumed throughout the circuit when Watt's Law ($P = IE$) is applied, leading engineers and technicians to refer to this dissipated power as *apparent power*.

b. The relationship between true power and apparent power in an AC RC circuit is referred to as the *power factor* and is determined by dividing true power by apparent power.

c. The power factor is also equal to the cosine of the phase angle, which represents the ratio of resistance to impedance, and can be expressed in the formula:

$$\text{cosine } \theta = \frac{R}{Z}$$

Information Sheet

36. Impedance in RC circuits

a. The total opposition to flow offered by both the resistor and the capacitor is called impedance.

b. Impedance is expressed in ohms.

c. Impedance is represented by the symbol Z.

d. The formula to solve for impedance is a variation of Ohm's Law, where impedance replaces resistance:

$$Z = \frac{E_a}{I_t}$$

e. Another formula to determine impedance can be used if resistance and inductive reactance are known:

$$Z = \sqrt{R^2 + X_C^2}$$

Note: The variations on this formula are:

$R = \sqrt{Z^2 - X_C^2}$ or $X_C = \sqrt{Z^2 - R^2}$

37. Phase shift in RC circuits

a. Phase shift in an RC circuit is a function of the resistance and the capacitance.

b. The phase angle theta (θ) of an RC circuit may be found mathematically by the use of trigonometric formulas, such as:

$$\theta = \arctan\frac{X_C}{R}$$

c. If the capacitor and resistor voltages are known, the phase angle can be calculated as:

$$\theta = \arctan\frac{E_C}{E_R}$$

Information Sheet

38. Capacitive reactance

a. Capacitive reactance is the opposition to AC current flow offered by a capacitor.

b. Capacitive reactance is inversely proportional to the capacitance of the capacitor voltage.

c. Capacitive reactance is inversely proportional to the frequency of the applied voltage.

Note: As the frequency of the AC increases, capacitive reactance decreases.

d. Capacitive reactance is represented by the symbol X_C.

e. The unit of measure for capacitive reactance is the ohm.

f. Capacitive reactance can be calculated by the formula

$$X_C = \frac{1}{2\pi f C}$$

39. Formulas to determine characteristics of series RC circuits

a. The current in an RC series circuit is determined by Ohm's Law ($I = E/R$).

b. The impedance of the series RC circuit is determined by the formula:

$$Z = \frac{E_a}{I_t}$$

c. If the resistance and capacitive reactance are known, impedance can be determined with the formula:

$$Z = \sqrt{R^2 + X_C^{\,2}}$$

d. Capacitive reactances in series are combined like resistances; $X_{Ct} = X_{C1} + X_{C2} + X_{C3}$.

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40. Formulas to determine characteristics of parallel RC circuits

a. The current in the resistive branch of an RC parallel circuit is determined by Ohm's Law

$$I = \frac{E}{R}$$

b. The current in the capacitive branch of an RC parallel circuit is determined by using Ohm's Law and substituting the capacitive reactance for resistance

$$I = \frac{E}{X_C}$$

c. Due to the phase difference between the resistance branch current and the capacitive branch current, total current is determined with the formula:

$$I_t = \sqrt{I_R^{2} + I_C^{2}}$$

d. The impedance of the parallel RC circuit is determined by the formula:

$$Z = \frac{E_a}{I_t}$$

e. If the resistance and capacitive reactance are known, impedance can be determined with the formula:

$$Z = \frac{RX_C}{\sqrt{R^2 + X_C^2}}$$

f. Capacitive reactances in parallel are combined like resistances in parallel using the reciprocal formula:

$$\frac{1}{X_{Ct}} = \frac{1}{X_{C1}} + \frac{1}{X_{C2}} + \frac{1}{X_{C3}}$$

Note: It is also convenient to use other electrical characteristics when examining parallel circuits with both resistance and reactance. These characteristics are the reciprocals of values with which you have worked. They include *susceptance*, which is the reciprocal of reactance measured in siemens, and *admittance*, which is the reciprocal of impedance measured in siemens. Thus, susceptance can be substituted for capacitive reactance in the reciprocal formula.

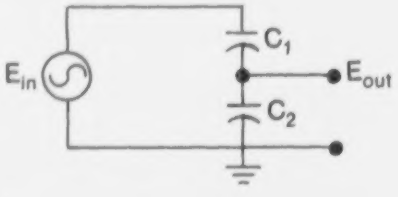
Information Sheet

41. Uses of capacitive circuits

a. A capacitive circuit can be used as a voltage divider.

Example:

$$E_O = \frac{E_{in} \times C_2}{X_{c1} + X_{c2}}$$



- The output voltage (E_{out}) of each individual capacitor is a function of the circuit current and the reactance for that capacitor and can be solved using Ohm's Law with reactance substituted for resistance; $E_{out} = IX_C$.

- Total divider circuit output can be calculated using the formula:

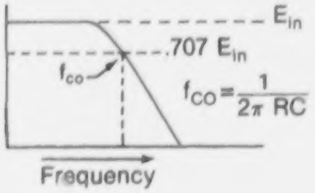
$$E_{out} = \frac{X_{C2}}{X_{C1} + X_{C2}} \times E_{in}$$

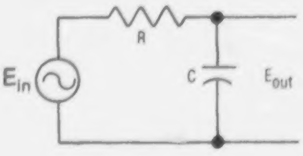
- If the capacitor values are known, output voltage can be calculated with the formula:

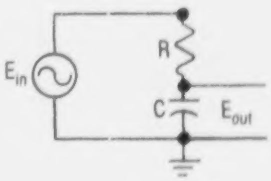
$$E_{out} = \frac{C_1}{C_1 + C_2} \times E_{in}$$

b. An RC circuit can be used as a low-pass filter circuit.

Example:







- At low frequencies, capacitive reactance is high, allowing most of the voltage to cross the capacitor so that low frequencies pass from input to output.

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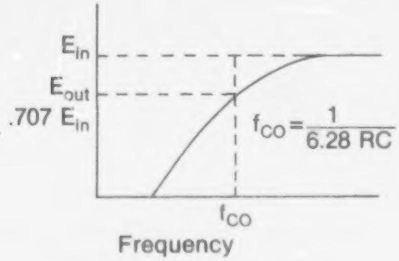
- At high frequencies, capacitive reactance is low, allowing most of the voltage to cross the resistor so that high frequencies are blocked from passing between the input and output.

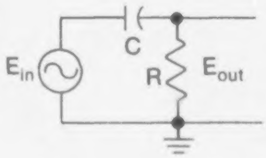
- The cut-off frequency (f_{CO}) is the point at which output drops to 0.707 of the input frequency and may be calculated with the formula:

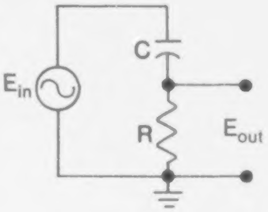
$$f_{CO} = \frac{1}{6.28\ RC}$$

c. An RC circuit can be used as a high-pass filter circuit applying the same principles as with a low-pass filter.

Example:

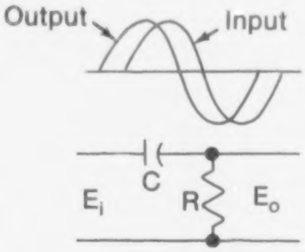


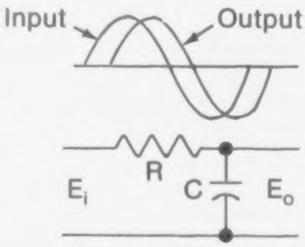




d. An RC circuit can be used to obtain a phase shift.

Example:





- The phase shift created by a capacitor network is dependent on frequency, so that a network must be used with a specific frequency and be designed to create a desired amount of phase shift.

- The amount of phase shift can be determined by finding the tangent of the phase angle from the voltages using the formula:

$$\text{tangent } \theta = \frac{E_R}{E_C}$$

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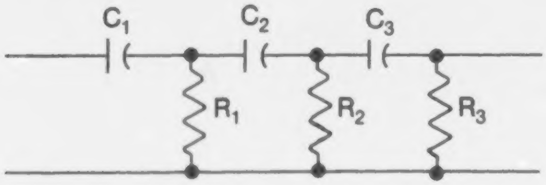
- If a phase shift of more than 60° is required, a series of networks will be required to create a cascade.

  Example:



42. Characteristics of series RCL circuits

a. Series resistive-capacitive-inductive (RCL) circuits contain resistance, capacitance, and inductance components connected in series.

b. Total reactance in the circuit is a combination of X_L and X_C.

c. When X_L is greater than X_C, the circuit behaves as an inductive circuit.

d. When X_C is greater than X_L, the circuit behaves as a capacitive circuit.

e. When X_L and X_C are equal, the circuit appears to be resistive and is referred to as *resonant*.

f. Net reactance (X_t) is equal to the difference between inductive reactance and capacitive reactance; $X_t = X_L - X_C$.

g. Impedance in an RCL circuit is calculated as:

$$Z = \sqrt{R^2 + X_t^2}$$

h. Voltage across the resistance (V_R) is in phase with the circuit current.

i. Voltage across the inductor (V_L) leads the circuit current by 90°.

j. Voltage across the capacitor (V_C) lags the circuit current by 90°.

k. Reactive voltage (V_t) is the vector sum of the inductive voltage and the capacitive voltage in accordance with the formula:

$$V_t = \sqrt{V_L^2 + V_C^2}$$

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l. The applied voltage is the vector sum of the resistive voltage and the reactive voltage in accordance with the formula:

$$E_a = \sqrt{V_R^2 + V_X^2}$$

43. Resonant characteristics of a series RCL circuit

a. Impedance is at its minimum value.

b. Circuit current is at its maximum level.

c. The phase angle between voltage and current is zero.

d. V_L and V_C are equal and are larger than E_a.

e. The resonant frequency of a series RCL circuit can be calculated through the formula:

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

f. The quality (Q) of the circuit can be calculated by dividing either the inductive or the capacitive reactance by the series AC resistance in accordance with the formula:

$$Q = \frac{X}{R}$$

g. Bandwidth (BW) for the series RCL resonant circuit is measured between the half-power points of the circuit and is calculated through the formula:

$$BW = \frac{f_r}{Q}$$

44. Characteristics of parallel RCL circuits

a. Parallel resistive-capacitive-inductive (RCL) circuits contain resistance, capacitance, and inductance components connected in parallel.

b. Current in the resistive branch is in phase with the voltage.

c. The current in the resistive branch of an RCL parallel circuit is determined by Ohm's Law ($I = E_a/R$).

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d. Current in the capacitive branch leads the voltage by 90°.

e. The current in the capacitive branch of an RCL parallel circuit is determined by using Ohm's Law and substituting the capacitive reactance for resistance ($I = E_a/X_C$).

f. Current in the inductive branch lags the voltage by 90°.

g. The current in the inductive branch of an RCL parallel circuit is determined by using Ohm's Law and substituting the inductive reactance for resistance ($I = E_a/X_L$).

h. The reactive current (I_x) is the difference between the current in the inductive branch (I_x) and the current in the capacitive branch (I_C).

i. When the inductive effects equal the capacitive effects, the circuit is resonant and is often referred to as a *tank circuit*.

j. Total current is determined with the formula:

$$I_t = \sqrt{I_R^2 + I_X^2}$$

k. The impedance of the parallel RCL circuit is determined by the formula:

$$Z = \frac{E_a}{I_t}$$

45. Resonant characteristics of a parallel RCL circuit

a. Impedance is at its maximum value.

b. Circuit current is at its minimum level and equals the resistive current.

c. The phase angle between applied voltage and total current is zero.

d. V_L and V_C are equal and are larger than E_a.

e. The resonant frequency of a parallel RCL circuit can be calculated through the formula:

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

Information Sheet

f. The quality (Q) of the circuit can be calculated by dividing inductive reactance by the total AC resistance in accordance with the formula:

$$Q = \frac{X_L}{R}$$

g. Bandwidth (BW) for the parallel RCL resonant circuit is measured between the half-power points of the circuit and is calculated through the formula:

$$BW = \frac{f_r}{Q}$$

46. Processes for conditioning signals

Note: As noted in Unit 1, one of the main differences between electrical and electronic applications is that electrical devices use electricity primarily for power while electronic devices use electricity to produce, modify, distribute, and output signals. Part of the modification process is referred to as *signal conditioning* or, when specifically applied to power in electrical or electronic devices, *power conditioning*. The purpose of signal conditioning is simply to make the signal more suitable for use by a particular device or for a specific function. Signal conditioning is normally achieved through one or more of the methods described below.

a. Amplification—Increasing of signal strength

b. Filtering—Separation of selected frequencies or groups of frequencies

c. Impedance matching—Causing the impedance of the source signal and the load signal to be equal or nearly equal

d. Modulation—Control of periodic aspects of a signal such as amplitude, frequency, or pulse width

e. Demodulation—Recovering original signal characteristics from a modulated signal

Note: Demodulation is sometimes defined as recovering the *intelligence* of a modulated signal due to the use of signals to carry data.

f. Conversion—Changing one signal characteristic to another

Examples: Analog to digital, digital to analog, voltage to current, current to voltage, current to frequency

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47. Devices and circuits involved in analog signal conditioning

Note: The study of electronics may actually involve six different kinds of signals: mechanical, thermal, magnetic, optical, chemical, and electrical. In this course, we will concentrate on electrical signals because virtually all other types of signals must be converted to electrical signals in order to be useful in the electronic system. Devices that convert one type of signal to another type are called *transducers.* Two types of devices that you have previously studied, *bridges* and *voltage dividers*, are often used to couple circuits involved in electrical signal conditioning. The devices and circuits listed below condition analog electrical signals. Your continuing studies will introduce you to specific types of each circuit.

a. Amplification

  - Amplifiers
  - Integrator circuits
  - Differentiator circuits
  - Inductors

b. Filtering

  - Low-pass filters
  - High-pass filters
  - Band-pass filters
  - Band-stop filters
  - Rectifier filters
  - Active filters

c. Impedance matching

  - Resistors
  - Inductors
  - Active filters

Information Sheet

d. Modulation/ Demodulation

- Frequency modulators/demodulators
- Amplitude modulators/demodulators
- Pulse amplitude modulators/demodulators

e. Conversion

- Oscillators
- Analog-to-digital converters
- Voltage-to-frequency converters
- Frequency-to-voltage converters
- Voltage-to-current converters
- Current-to-voltage converters

48. Devices and circuits involved in digital signal conditioning

Note: Digital pulses consist of alternating high and low signals. Thus, their conditioning characteristics tend to be less dynamic than analog signals. Devices and circuits used to condition digital signals can be largely classified as converters and filters that perform their functions based on the structure of a string of digital pulses called a *word*. The actual conditioning may be done by hardware or through a software function. These circuits and the processes used are covered in greater depth in the other two books in the General Electronics Technician series, *Discrete Semiconductor Devices and Circuits* and *Digital Electronics and Introduction to Microprocessors.*

a. Digital-to-analog converter (DAC)—Takes periodic samples of an analog signal and represents the sample taken at a point in time as a digital value

b. Logic gate—Receives digital inputs on which a logical combining is performed to produce a digital output signal

c. Programmable logic controller (PLC)—Receives digital input signals and conditions them in accordance with internal software processing instructions to produce a digital output signal

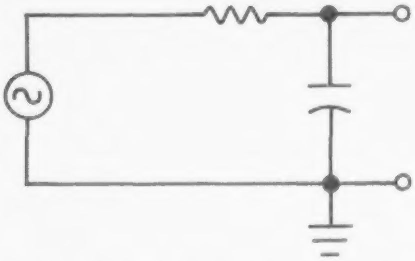
d. Digital filter—Produces output signals based on current and past input signals and, in some cases, past output signals

Note: Digital filters operate in accordance with mathematical equations called *transfer functions*. Those digital filters that take into account current and past inputs are called *non-recursive filters*, while those that additionally take into account their past outputs are called *recursive filters*.

49. AC differentiator and integrator circuits

a. A differentiator circuit or *differentiating network* is an RC circuit that contains a series capacitor and a shunt resistor and is constructed in such a way that the output voltage is a derivative of the input voltage.

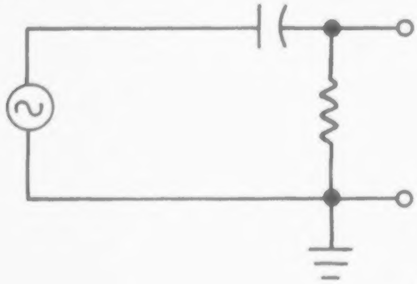
Example:



- Differential is the difference between two quantities, such as input voltage and output voltage.
- A differentiator allows the control of a circuit so that a specific ratio of differentials is maintained, such as keeping the same ratio between input voltage and output voltage over time.

b. An integrator circuit or *integrating network* is an RC circuit with a series resistor and a shunt capacitor and is constructed in such a way that the output voltage is (or is proportional to) the time integral of the input voltage.

Example:

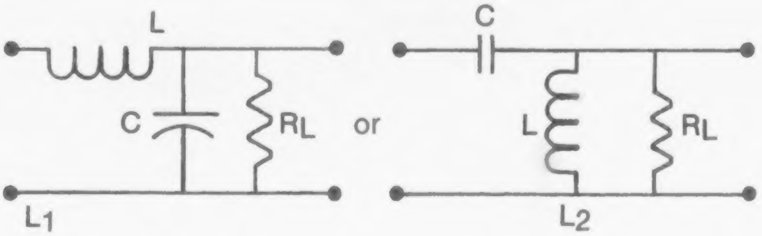


Information Sheet

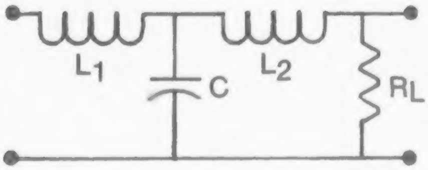
- The integrator circuit provides continuous adding capabilities and allows tracking of a quantity over time as it accumulates.
- An integrator allows the control of a circuit by monitoring accumulated values and responding to them, such as tracking electrical usage over time or switching a circuit when an accumulated quantity is reached.

50. Configurations of filter circuits

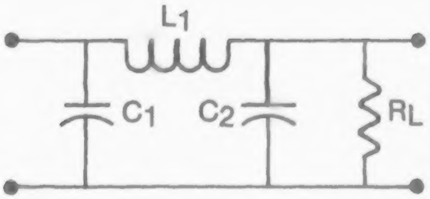
a. L-filter



b. T-filter



c. π-filter



Information Sheet

51. Operation of types of filter circuits

a. Capacitive filter—Reduces the voltage or current ripple by providing storage for part of the charge

b. Choke filter—Uses an inductor to oppose changes in current, thus reducing ripple

c. Band-stop filter—Prevents bandwidths of certain undesired frequencies from going through the circuit

d. Band-pass filter—Allows only bandwidths of certain desired frequencies to go through the circuit

e. By-pass filter—Routes signals of certain bandwidths around a circuit or section of a circuit

52. Differences in the operation of a high-pass filter and a low-pass filter

a. High-pass filter—Uses coupling capacitance in series with the load and choke inductance in parallel with the load

b. Low-pass filter—Uses bypass capacitance in parallel with the load and choke inductance in series with the load

53. Guidelines for impedance matching

a. The best efficiency of power transfer occurs when the source impedance is equal to the load impedance.

b. In a circuit, impedance is normally matched through the use of external resistors.

54. Rectangular notation

Note: It is often convenient to be able to work with impedance and other values in forms that allow easy determination of phase angles, inductive reactance, and capacitive reactance for circuit design and analysis. One approach is to use coordinate representations of electrical values so that value changes can be plotted easily. The two most common methods of coordinate representation in electronics are rectangular notation and polar notations.

a. Uses the letter *j* to indicate the direction of rotation (clockwise or counterclockwise) of a vector.

b. A +j indicates the rotation of a vector in a counterclockwise direction through an angle of 90°.

Information Sheet

c. A -j indicates the rotation of a vector in a clockwise direction through an angle of 90°.

d. A counterclockwise rotation indicates that the circuit has increasingly inductive characteristics.

Example: +j75 is rectangular notation for an inductive reactance of 75 ohms

e. A clockwise rotation indicates that the circuit has increasingly capacitive characteristics.

Example: -j85 is rectangular notation for a capacitive reactance of 85 ohms

f. Rectangular notation can be converted to polar notation by vector summation of rectangular components.

Example: The impedance of a series RC circuit with a 250-ohm resistance and 100-ohm capacitive reactance can be written in rectangular form as

$$Z = 250 - j100$$

$$Z = \frac{X}{\text{sine } \theta}$$

$$\text{tangent } \theta = \frac{X}{R} = \frac{100}{250} = 0.4000,$$

therefore θ is 21.8° and sine $\theta = 0.3717$

$$Z = \frac{X}{\text{sine } \theta} = \frac{100}{0.3714} = 269$$

$$Z = 269 -\angle 21.8^\circ$$

55. Polar notation

a. Uses a numeric representation of the phase angle enclosed in an angle symbol, ∠.

b. A +∠ indicates the rotation of a vector in a counterclockwise direction.

c. A -∠ indicates the rotation of a vector in a clockwise direction.

Information Sheet

d. A counterclockwise rotation indicates that the circuit has increasingly inductive characteristics.

Example: +∠45° is polar notation for an inductive circuit with a 45° phase angle

e. A clockwise rotation indicates that the circuit has increasingly capacitive characteristics.

Example: -∠45° is polar notation for a capacitive circuit with a 45° phase angle

f. Polar notation can be converted to rectangular notation through trigonometric conversion and the use of the formula Z = Z cosine ±jZ sine.

Example: The impedance of a series RC circuit with a 250-ohm resistance and 100-ohm capacitive reactance can be notated in polar form as

$Z = 269 -\angle 21.8^\circ$

$Z = Z \text{ cosine } -jZ \text{ sine}$

$Z = 269 \text{ cosine } 21.8^\circ -j\ 269 \text{ sine } 21.8^\circ$

$Z = 269\ (0.9285) -j\ 269\ (0.3714)$

$Z = 250 -j100$

AC and AC Circuits
Unit 5

Assignment Sheet 1—Determine Sine Wave Conversions

Name ______________________________ Overall Rating ____________

Evaluation criteria **Rating**

- Directions have been followed ________
- Minimum of 80 percent of answers are correct ________

Note: Each correct answer is worth 10 points.

Introduction: There are times when a technician needs to know the value of an electrical characteristic in terms other than what can be directly measured with the equipment available. For example, the technician may have only a voltmeter and need to know peak-to-peak voltage. Fortunately, the relationships among electrical characteristics are consistent so that mathematical constants can be used to make these conversions. Just as Ohm's Law can be used to determine unknown values, the use of constants can allow a technician to convert one instrument reading to another value. This assignment sheet provides practice in how to convert to and from sine wave values.

Directions: The table below shows the constants that define the relationships among waveform values. Use the table to answer the questions on the next page. Write your answers in the blanks provided with each question.

Table 1: Sine wave conversion constants

From *To*	**Effective (RMS)**	**Average**	**Peak**	**Peak-to-peak**
Effective (RMS)	--	0.900	1.414	2.828
Average	1.110	--	1.571	3.142
Peak	0.707	0.637	--	2.000
Peak-to-peak	0.354	0.318	0.500	--

Assignment Sheet 1

1. An oscilloscope shows that the peak voltage of an AC wave is 155.6 volts. What is the voltage that would be read on the AC scale of a multimeter—that is, the RMS voltage value?

____

2. If your voltmeter reads 25 volts (effective value), what would be the peak voltage shown on an oscilloscope (peak value)?

____

3. What would the peak-to-peak voltage be for a voltmeter reading of 25 volts?

____

4. If the peak value of a sine wave is 100 volts, what is the average value of one alternation?

____

5. If the peak value of a sine wave is 220 volts, what is the peak-to-peak value?

____

6. An oscilloscope shows a peak-to-peak value of 120 volts. What is the RMS value?

____

7. The average voltage of an oscilloscope display is 78 volts. What is the RMS value?

____

8. The peak-to-peak value of a sine wave is 148.6 volts. What would the average value be?

____

9. A multimeter shows a circuit's RMS is 28.7 volts. What would the average value be?

____

10. After determining from the sine wave peak that the average value was 88.2 volts, a technician decides that the peak-to-peak value is also required, but the circuit is no longer available. What value for the peak-to-peak should the technician calculate?

____

AC and AC Circuits
Unit 5

Assignment Sheet 2—Compute Period

Name ______________________________ Overall Rating ____________

Evaluation criteria	Rating
• Directions have been followed	________
• Minimum of 80 percent of answers are correct	________
Note: Each correct answer is worth 20 points.	

Introduction: There are a number of ways to define the value of an alternating current. The most common method is to define its *frequency*. The frequency of an AC waveform is a measurement of how many cycles the current completes within a given amount of time. The normal unit of measure for frequency is Hertz, with 1 Hertz being equal to 1 cycle per second. Thus, 60 Hz AC completes 60 cycles per second. Another measurement of interest to the electronics technician is *period*, which is defined as the time required to complete one cycle. Consequently, if the frequency of a current is known, the period can be determined by dividing one second by the number of cycles per second, as in the following formula:

$T = \frac{1}{f}$, where T equals the period and f equals the frequency.

Directions: Read the problems below and perform the required calculations to determine period and frequency as required. Write your answers in the space provided with each schematic.

1. What is the period of a signal with a frequency of 120 Hz?

   ____

2. An FM radio station broadcasts on a frequency of 104 MHz. What is the period of the broadcast signal?

   ____

Assignment Sheet 2

3. A technician is working with a 60 Hz current which needs to be converted to a frequency of 120 Hz. To make this conversion, should the period be increased or decreased?

____

4. Radio waves travel at the speed of light or approximately 186,000 miles per second. If a radio station is broadcasting on a frequency of 1200 KHz, what is the distance traveled by a wave during one cycle?

____

5. While the standard AC in the United States is 120 volts at 60 Hertz, most European countries have a 220/240 VAC at 50 Hertz. What is the period for European AC?

____

AC and AC Circuits
Unit 5

Assignment Sheet 3—Determine Current Flow Direction

Name ______________________________ Overall Rating ____________

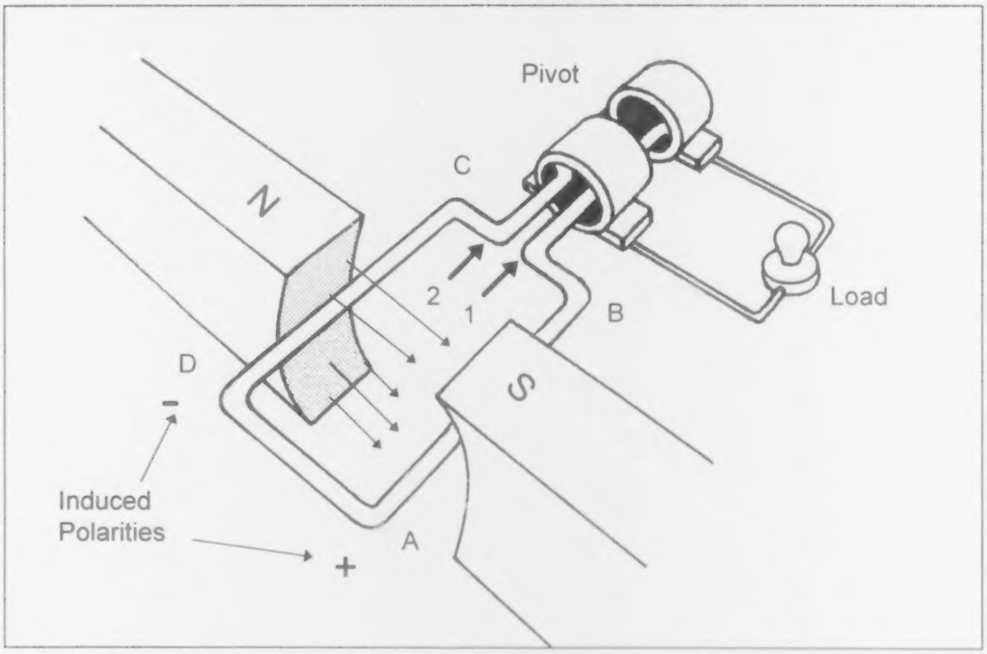
Evaluation criteria	**Rating**
• Directions have been followed	________
• Minimum of 86 percent of answers are correct	________
Note: Each correct answer is worth 14 points.	

Introduction: The natural output of a generator is alternating current because the rotation of the armature induces electrical flow but the direction of flow changes with the changes in induction paths. The left-hand rule for generators was developed to help technicians recognize the direction of electron flow in a generator, even as it changes. In this assignment sheet, you will be able to apply the left-hand rule for generators to determine the direction of current flow and other characteristics of electromagnetic induction.

Directions: Study the drawing of an AC generator on the next page and answer the questions that follow it. Write your answers in the spaces provided with each question.

Note: Assume that the direction of armature rotation is clockwise as viewed from the closed end of the loop. Therefore, in the state as shown, Leg 1 of the loop is moving down and Leg 2 is moving up.

Assignment Sheet 3



1. In the position shown, does current flow from A to B or from B to A in Leg 1?

____

2. In the position shown, does current flow from C to D or from D to C in Leg 2?

____

3. In the position shown, does the current entering the load circuit come from Point B or Point C?

____

4. Once the armature rotates 180º from the position shown, will the flow of current in Leg 1 be from A to B or from B to A?

____

5. Once the armature rotates 180º from the position shown, will the flow of current in Leg 2 be from C to D or from D to C?

____

Assignment Sheet 3

6. Once the armature rotates 180° from the position shown, does the current entering the circuit come from Point B or Point C?

____

7. Describe the direction of current flow at Point C once the armature rotates 90° from the position shown.

____

AC and AC Circuits
Unit 5

Assignment Sheet 4—Solve for Total Inductance

Name ______________________________ Overall Rating __________

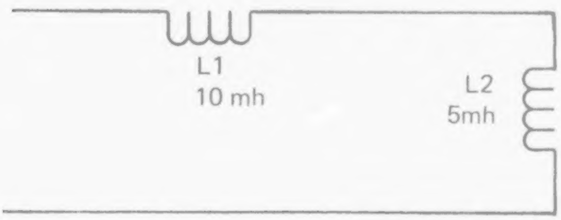
Evaluation criteria	Rating
• Directions have been followed	______
• Minimum of 80 percent of answers are correct	______
Note: Each correct answer is worth 20 points.	

Introduction: The symbol for inductance is L, and for a technician to understand the operation of a circuit with induced currents, the total inductance value must be known. In this assignment sheet, you will practice determining the expected total inductance of a circuit.

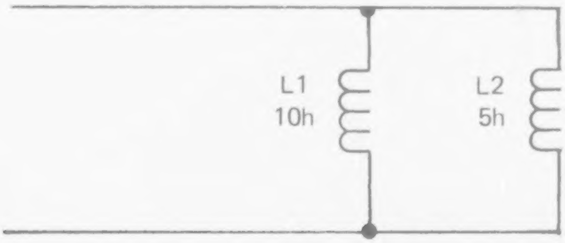
Directions: Study the schematics below and on the next page and determine the total inductance in each circuit. Write your answers in the spaces provided with each drawing.

Note: Assume that there is no mutual inductance in any of the circuits.

1. L_t = __________

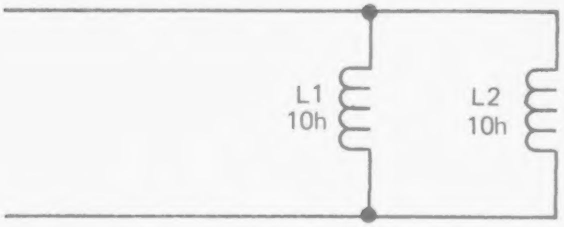


2. L_t = __________

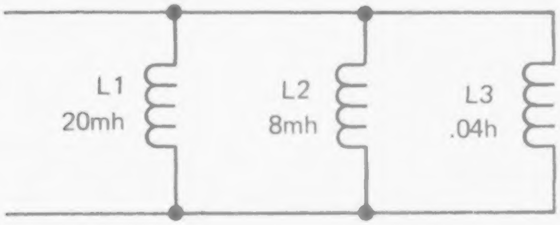


Assignment Sheet 4

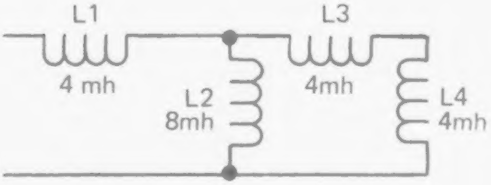
3. L_t = ____________


L1
10h
L2
10h

4. L_t = ____________


L1
20mh
L2
8mh
L3
.04h

5. L_t = ____________


L1
4 mh
L2
8mh
L3
4mh
L4
4mh

AC and AC Circuits
Unit 5

Assignment Sheet 5—Compute Inductive Reactance

Name ____ Overall Rating ______________

Evaluation criteria	**Rating**
• Directions have been followed	________
• Minimum of 80 percent of answers are correct	________

Note: Each correct answer is worth 20 points.

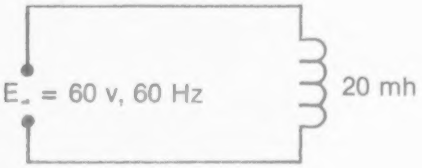
Introduction: The formula for calculating inductive reactance is

$$X_L = 2\pi fL$$

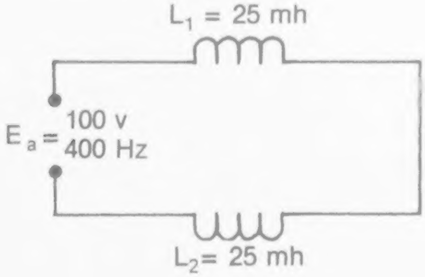
Variations in frequency and inductance will lead to differences in reactive inductance as demonstrated in the problems included in this assignment sheet.

Directions: Study the schematics below and on the next page and determine the reactive inductance in each circuit. Write your answers in the spaces provided with each drawing.

1. X_L = ____________

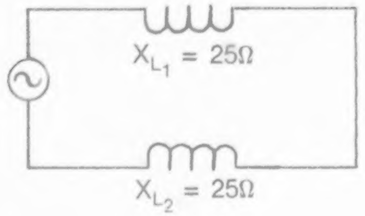


2. X_L = ____________

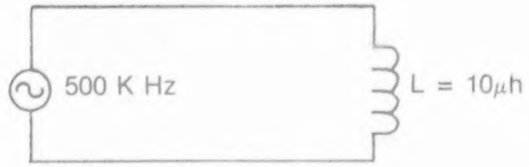


Assignment Sheet 5

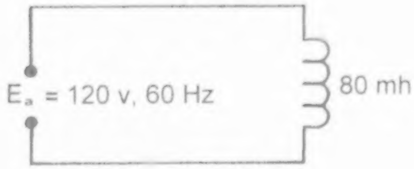
3. X_{Lt} = ____________


$X_{L_1} = 25\Omega$
$X_{L_2} = 25\Omega$

4. X_L = ____________


500 K Hz
$L = 10\mu h$

5. X_L = ____________


E_a = 120 v, 60 Hz
80 mh

AC and AC Circuits
Unit 5

Assignment Sheet 6—Compute Applied Voltage and Impedance of RL Circuits

Name ______________________________ Overall Rating ____________

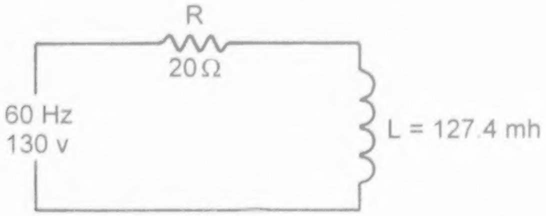
Evaluation criteria	**Rating**
- Directions have been followed	________
- Minimum of 80 percent of answers are correct	________
Note: Each correct answer is worth 5 points.	

Introduction: To this point, your studies have shown you how electrical characteristics vary for different types of circuits. Beginning with Ohm's Law, you have learned how to calculate electrical characteristics of circuits, such as voltage and resistance. Since then, you have learned how to calculate other characteristics such as impedance and how inductors affect a circuit. In this assignment sheet, you will apply the formulas that you have learned to compute values of circuit characteristics, including the formula for impedance:

$$Z = \frac{E_a}{I_t} \quad \text{or} \quad Z = \sqrt{R^2 + X_L^2}$$

Directions: Study the schematics below and on the next page and determine the values requested. Write your answers in the spaces provided with each drawing.

1.



a. X_L = __________

b. Z = __________

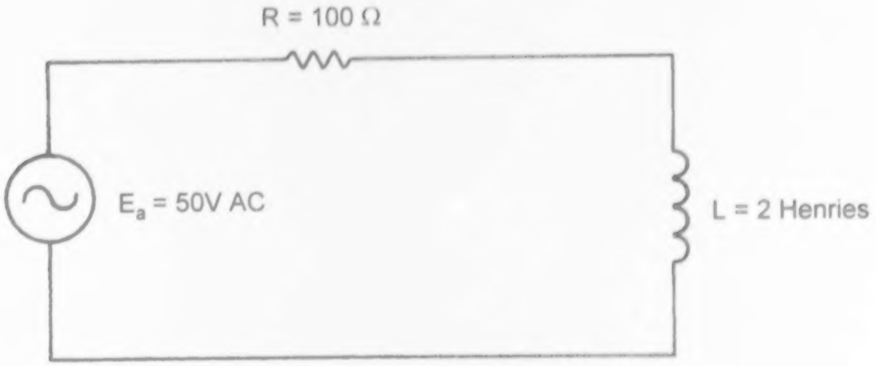
c. E_R = __________

d. E_L = __________

e. I_T = __________

Assignment Sheet 6

2.


R = 100 Ω
E_a = 50V AC
L = 2 Henries

a. X_L = ____________

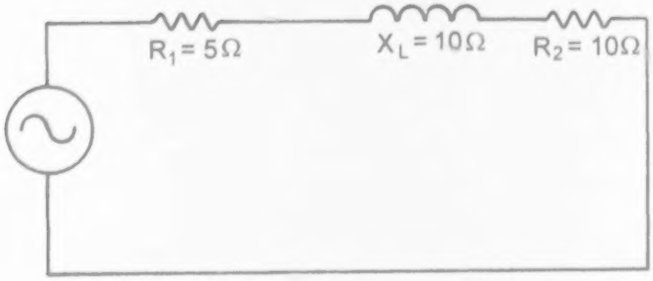
b. Z = ____________

c. E_R = ____________

d. I_R = ____________

e. I_T = ____________

3.

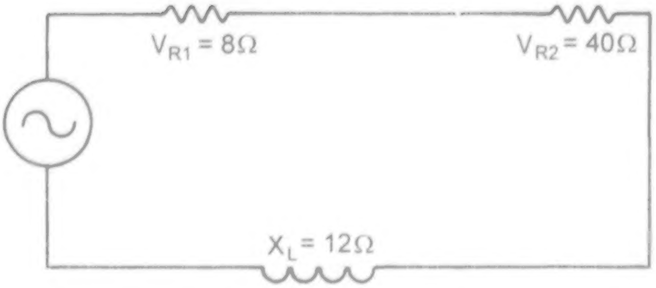

R₁ = 5Ω
X_L = 10Ω
R₂ = 10Ω

a. Z = ____________

b. X_L = ____________

Assignment Sheet 6

4.


$V_{R1} = 8\Omega$
$V_{R2} = 40\Omega$
$X_L = 12\Omega$

a. $Z =$ __________

b. $X_L =$ __________

c. $E_{R1} =$ __________

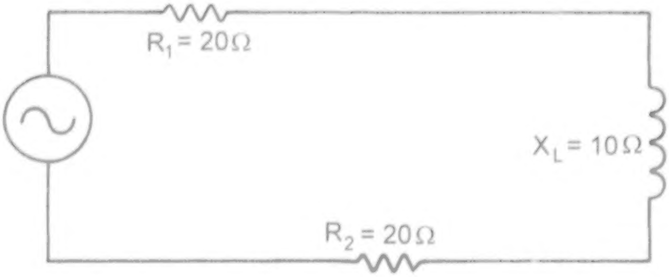
d. $E_{R2} =$ __________

e. $I_{R1} =$ __________

f. $I_{R2} =$ __________

g. $I_T =$ __________

5.


$R_1 = 20\Omega$
$X_L = 10\Omega$
$R_2 = 20\Omega$

a. $Z =$ __________

b. $X_L =$ __________

AC and AC Circuits
Unit 5

Assignment Sheet 7—Compute Inductor Quality

Name ______________________________ Overall Rating ____________

Evaluation criteria	**Rating**
• Directions have been followed	________
• Minimum of 80 percent of answers are correct	________
Note: Each correct answer is worth 20 points.	

Introduction: Two inductors may have the same L value. However, other characteristics of the two components may differ. For example, one may have a higher resistance. In an actual circuit application, these differences affect circuit performance. Thus, another inductor characteristic is called *quality* and is represented by the letter Q. Quality is calculated with the formula:

$$Q = \frac{X_L}{R_S}$$

Directions: Read the statements below and on the following pages. Then calculate the inductor Q based on each description. Write your answers in the spaces provided with each description.

1. A coil has an inductive reactance of 300 ohms and a resistance of 0.5 ohms. What is its Q value?

   ____

2. An inductor with a value of 500 mh and a resistance of 0.5 ohm is used in a circuit with an applied voltage of 10 volts at 60 Hertz. What is its Q value?

   ____

3. A technician determined that a coil with an internal resistance of 3 ohms exhibits an inductive reactance of 360 ohms in a particular circuit application. As a result, the technician stated, "The Q value of the inductor is 120 ohms." Is this statement correct, and, if not, what is wrong with the statement?

   ____

Assignment Sheet 7

4 Two inductors are rated at 600 mh inductance. Inductor A has an internal resistance of 0.45 ohm, while Inductor B has a resistance of 0.65 ohm. Which inductor has the higher Q value?

____

5 An inductor in a circuit exhibits a Q value of 800. If the angular velocity of the circuit is increased, will the Q value increase or decrease?

____

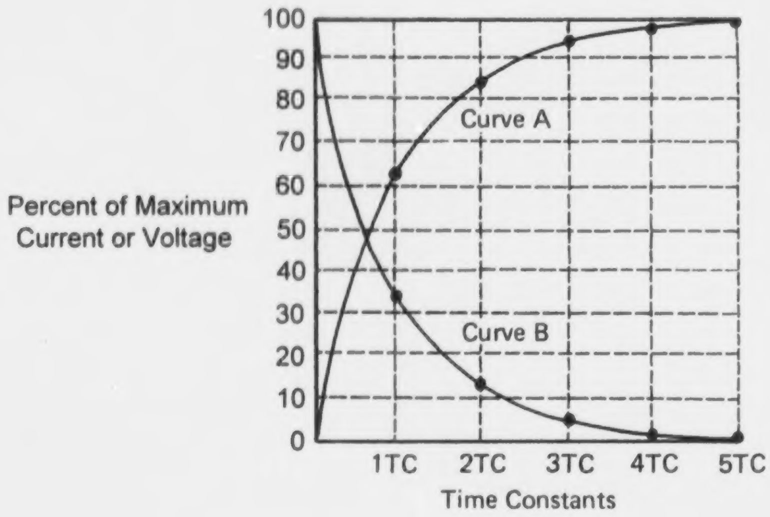
AC and AC Circuits
Unit 5

Assignment Sheet 8—Solve Time Constant Problems

Name ______________________________ Overall Rating ____________

Evaluation criteria	**Rating**
• Directions have been followed	________
• Minimum of 90 percent of answers are correct	________
Note: Each correct answer is worth 10 points.	

Introduction: In series RL circuits, current increases and decreases according to a predictable pattern. Power in a circuit does not instantly jump to 100 percent when current is applied or drop to 0 percent when current is removed. The rates of increase and decay, when graphed against a time line, would show the patterns represented in the graph below, with Curve A representing the increase to 100 percent, and Curve B showing the decay to 0 percent. The time line is labeled time constants because the actual time interval will vary based on how frequency and other factors are defined.



Assignment Sheet 8

Directions: Using the time constant graph on the previous page, answer the following questions. Write your answers in the spaces provided with each question.

1. How many time constants are required for current to rise to 100 percent of its maximum value?

   ____

2. Power has been applied to a circuit. What is the approximate percentage of maximum voltage reached after one time constant?

   ____

3. If power is removed, during which time constant interval (1-5) does the circuit show the greatest drop in voltage?

   ____

4. At what time constant interval (1-5) does a circuit reach approximately 95 percent of its maximum current when power is applied?

   ____

5. If the maximum voltage of a circuit is 120 volts, what will be its approximate voltage two time constants after power is applied?

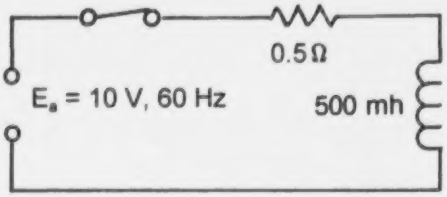
   ____

6. A 30-ampere circuit has a time constant of 0.5 seconds. If the circuit is operating at maximum amperage when power is removed, what is the approximate amperage of the circuit one second after power is removed?

   ____

Assignment Sheet 8

7. The switch is closed on the circuit illustrated below.



a. What is the maximum current that the circuit will produce?

____

b. What is the value of the time constant for this circuit?

____

c. How much time will be required to reach 40 mA after the switch is closed?

____

d. If the switch is opened, how long will it take the circuit to drop to 0 volts?

____

AC and AC Circuits
Unit 5

Assignment Sheet 9—Compute Capacitance Values

Name ______________________ Overall Rating __________

Evaluation criteria	**Rating**
• Directions have been followed	______
• Minimum of 87 percent of answers are correct	______
Note: Each correct answer is worth 12.5 points.	

Introduction: Capacitors are used in circuits to help regulate the amount of excess electrons. There are two values related to capacitance that are important for the technician to understand. First, there is the charge capacity of an individual capacitor component. This is a product of the applied voltage and the capacitance value of the capacitor. Secondly, there is the total capacitance in a circuit or in the branch of a circuit. This assignment sheet requires you to determine both values. To do so, you will use the formulas:

$$C = \frac{Q}{E} \qquad \text{and} \qquad C_t = \frac{C_1 \times C_2}{C_1 + C_2} \qquad \text{or} \qquad C_t = C_1 + C_2 + C_3 \ldots$$

Directions: Study the circuit descriptions and schematics below and on the next page. Determine the charge or capacitance in each circuit or portion of the circuit as requested. Write your answers in the spaces provided with each drawing.

1. Calculate the amount of charge developed on the plates of capacitors with the following values if 50 volts is applied to them.

   a. 2 F ______________

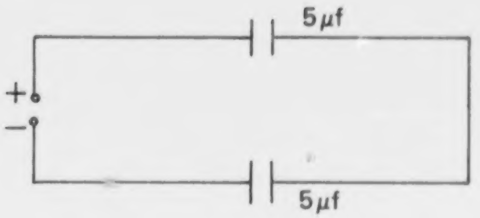
   b. 2 μF ______________

   c. 2 pF ______________

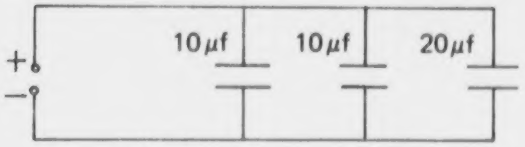
   d. 100 μF ______________

Assignment Sheet 9

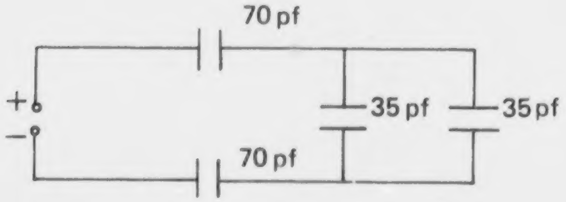
2. C_t = ____________



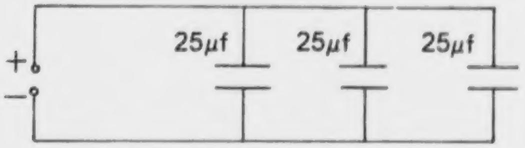
3. C_t = ____________


+
−
10 µf
10 µf
20 µf

4. C_t = ____________


70 pf
+
−
35 pf
35 pf
70 pf

5. C_t = ____________


+
−
25µf
25µf
25µf

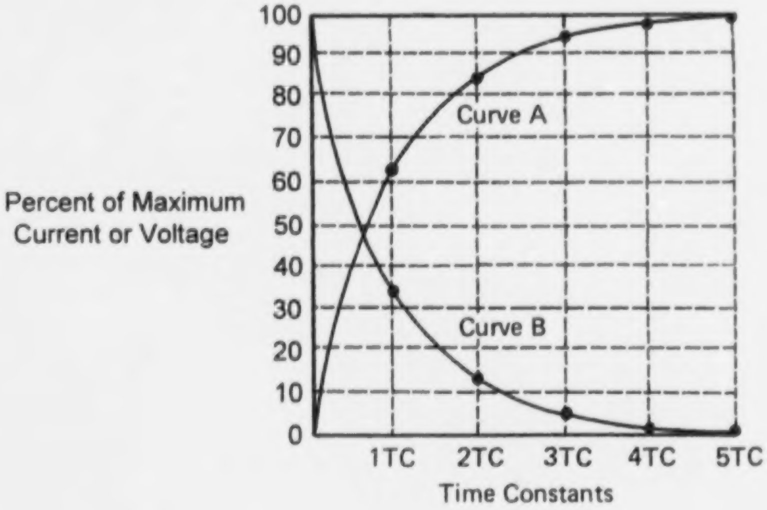
AC and AC Circuits
Unit 5

Assignment Sheet 10—Compute RC Time Constants

Name ______________________________ Overall Rating ____________

Evaluation criteria	**Rating**
• Directions have been followed	______
• Minimum of 86 percent of answers are correct	______
Note: Each correct answer is worth 7 points.	

Introduction: The rate of charge and discharge in RC circuits is governed by time constants in the same way that power buildup and drop-off occurs in RL circuits. By using the chart below, you will be able to solve the time constant problems in this assignment sheet.



Assignment Sheet 10

Directions: Answer the questions below and on the following page. Write your answers in the spaces provided with each question.

1. The voltage across a capacitor will build to a maximum of 120 volts. What will the voltage be after two time constants?

   ____

2. During discharge, a current of 24 amps across a resistor drops to what value after one time constant?

   ____

3. How many time constants are required for full discharge?

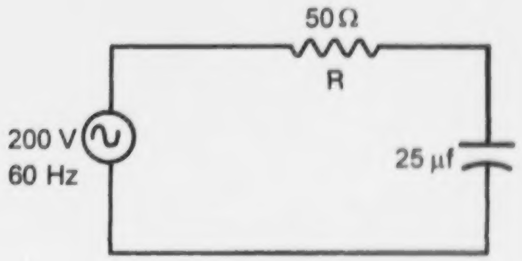
   ____

4. What is the interval of a time constant in circuits with the following values:

	Resistance	Capacitance	Time Constant
a.	1 megaohm	1 µF	
b.	1 kilohm	20,000 µF	
c.	1500 ohms	200 pF	
d.	47 kilohms	30 µF	

Assignment Sheet 10

5. Determine the requested values for the following circuit.



a. What is the maximum current for the circuit?

____

b. What will the current value be after two time constants during charge?

____

c. What is the value of E_C after three time constants during charge?

____

d. What is the value of E_R after three time constants during charge?

____

e. What is the current after four time constants during discharge?

____

f. What is the value of E_C after two time constants during discharge?

____

g. What is the value of E_R after two time constants during discharge?

____

AC and AC Circuits

Unit 5

Assignment Sheet 11—Compute Capacitive Reactance

Name ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
• Directions have been followed	______
• Minimum of 87 percent of answers are correct	______
Note: Each correct answer is worth 12.5 points.	

Introduction: Just as a circuit with an inductor exhibits inductive reactance, a circuit with a capacitor produces capacitive reactance. Represented by the symbol X_C, capacitive reactance is calculated with the formula:

$$X_C = \frac{1}{2\pi fC}$$

Directions: Use the formula to determine the values requested below and on the following pages. Write your answers on the blanks beside each question.

1. Compute X_C for the following values of C and f:

	Capacitance	Frequency	Capacitive Reactance
a.	10,000 μF	10 Hz	________________
b.	10 μF	60 Hz	________________
c.	27 F	120 Hz	________________
d.	50 μF	60 Hz	________________
e.	20,000 pF	50 Hz	________________

2. A technician is trying to create a capacitive reactance of 40 ohms using a 0.05 μF capacitor. What frequency of current should be used to develop the required capacitive reactance?

____

Assignment Sheet 11

3. In the previous problem, if the technician decides to increase the capacitive reactance to 50 ohms, should the frequency be increased or decreased?

____

4. Angular velocity is the measure of a rotating vector such as an AC sine wave using a unit of measure of radians per second. The formula for angular velocity is,

$$AV = 2\pi f^2$$

   a. What is the angular velocity of a circuit operating at 60 cycles per second?

   ____

   b. What is the angular velocity of a circuit operating at 50 Hz?

   ____

   c. If the frequency is increased, will angular velocity increase or decrease?

   ____

AC and AC Circuits
Unit 5

Assignment Sheet 12—Determine Phase Relationships in RC Circuits

Name ______________________________ Overall Rating ____________

Evaluation criteria	**Rating**
• Directions have been followed	________
• Minimum of 84 percent of answers are correct	________
Note: Each correct answer is worth 16 points.	

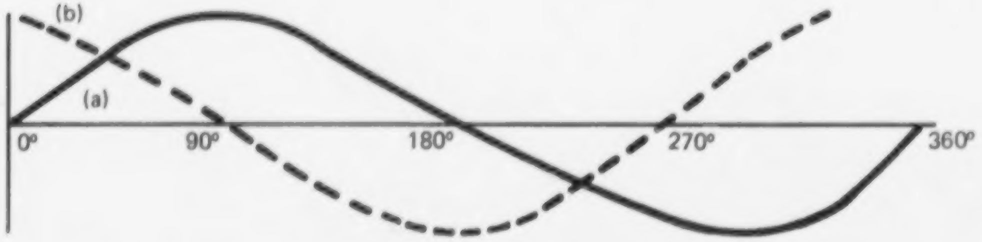
Introduction: Clues about how a circuit is functioning can be found in its output signal on an oscilloscope. Additionally, vector graphs can be used to describe how circuits are functioning. This assignment sheet will allow you to demonstrate that you understand how to interpret such graphic representations and that you understand the meaning of power factor values.

Directions: Study the drawings below and on the next page and answer the questions. Write your answers in the spaces provided.

1. In the figure below, which line (A or B) represents AC current in a capacitive circuit and which represents AC voltage?

   Current ______________

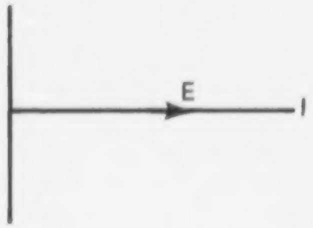
   Voltage ______________



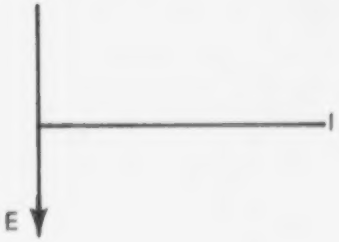
Assignment Sheet 12

2. The vector drawings below represent purely capacitive, purely resistive, and RC circuits using alternating current. Label each in the spaces provided.

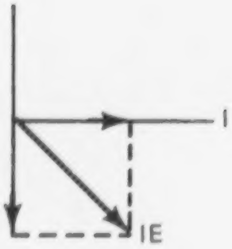
a. ____________________



b. ____________________



c. ____________________



3. Explain what is meant by a power factor of 1.

____

____

____

AC and AC Circuits
Unit 5

Assignment Sheet 13—Compute Values of RC Circuits

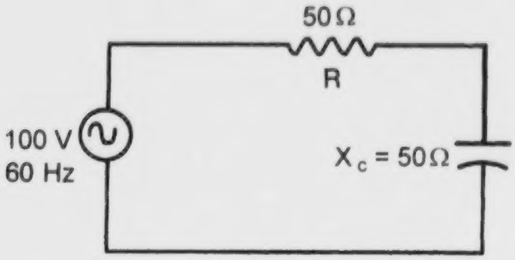
Name ______________________________ Overall Rating ____________

Evaluation criteria	Rating
• Directions have been followed	______
• Minimum of 84 percent of answers are correct	______
Note: Each correct answer is worth 8 points.	

Introduction: When a circuit combines both resistive and capacitive components, the technician must understand the interrelationship of the circuit values in order to properly analyze its operation. This includes an understanding of both the resistive and capacitive values, as well as phase relationships and values of other electrical characteristics, such as current and voltage. You will demonstrate your understanding of RC characteristics in this assignment sheet.

Directions: Study the schematics shown below and on the next page. Determine the values requested. Write your answers in the space provided with each schematic.

1.

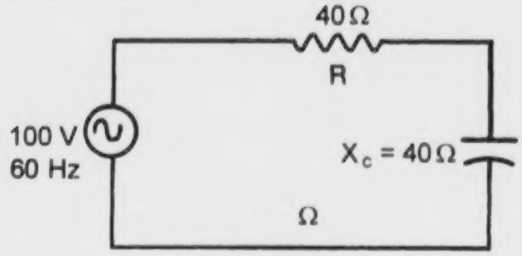


a. V_R = __________

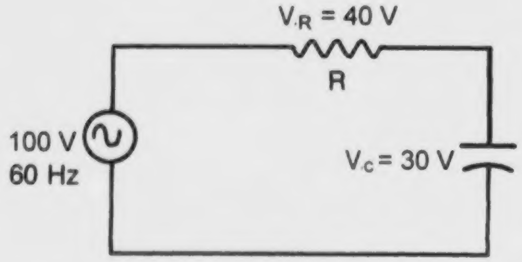
b. V_C = __________

Assignment Sheet 13

2. Z = __________


40 Ω
R
100 V
60 Hz
X_c = 40 Ω
Ω

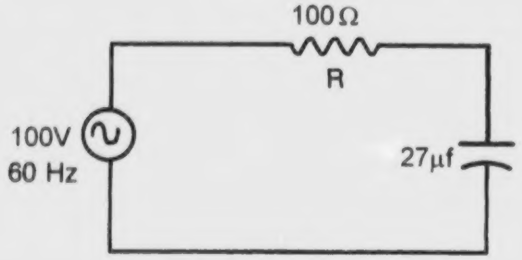
3.


V_R = 40 V
R
100 V
60 Hz
V_c = 30 V

a. E_a = __________

b. θ = __________

4.


100 Ω
R
100V
60 Hz
27μf

a. X_C = __________

b. Z = __________

c. I = __________

d. E_R = __________

e. E_C = __________

f. θ = __________

g. PF = __________

AC and AC Circuits
Unit 5

Assignment Sheet 14—Solve for Reactance

Name ______________________________ Overall Rating ____________

Evaluation criteria	Rating
• Directions have been followed	______
• Minimum of 80 percent of answers are correct	______
Note: Each correct answer is worth 10 points.	

Introduction: Previous assignment sheets have dealt with inductive reactance and capacitive reactance. However, a circuit can contain both inductive and capacitive components. Therefore, the technician must be able to compute total reactance. Additionally, by weighing the value of the components and their effect on the circuit, the technician can define the circuit as primarily capacitive or primarily inductive. The problems below will help you to explore these concepts.

Directions: Study the circuits described below and on the next page and determine whether the circuit is capacitive or inductive. Also determine the circuit values as requested. Write your answers in the spaces provided with each item.

1. Determine the total reactance for each circuit described below. Also state whether the circuit is capacitive or inductive.

   Note: Assume that the circuits are series circuits with no resistance.

	X_L	X_C	X_T	Capacitive or inductive
a.	10 ohms	5 ohms		
b.	5 ohms	10 ohms		
c.	15 ohms	15 ohms		
d.	15 ohms	20 ohms		
e.	20 ohms	15 ohms		

Assignment Sheet 14

2. If a 1 mH coil is in series with a 1 μF capacitor, will the circuit be capacitive or inductive at the following frequencies:

    a. 3 Hz ____________

    b. 1 KHz ____________

    c. 600 Hz ____________

    d. 60 Hz ____________

    e. 1 MHz ____________

AC and AC Circuits
Unit 5

Assignment Sheet 15—Solve for Impedance

Name ____ Overall Rating ____________

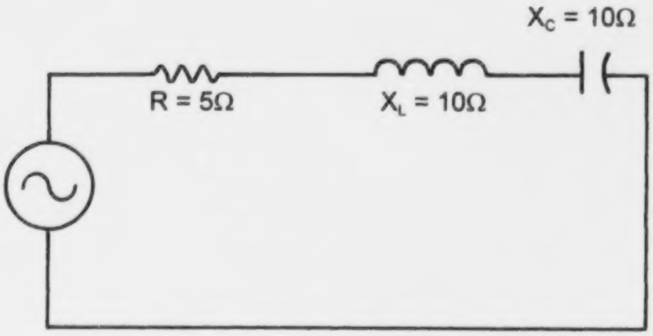
Evaluation criteria	Rating
• Directions have been followed	________
• Minimum of 84 percent of answers are correct	________

Note: Each correct answer is worth 16 points.

Introduction: In this unit, you have learned to use a tool called the *impedance triangle* to assess the effects of impedance in RCL circuits. In this assignment sheet, you will be able to use that tool to solve for impedance while also determining effective reactance.

Directions: Study each circuit diagram and answer the questions that accompany it. Write your answers in the space provided with each question.

1.

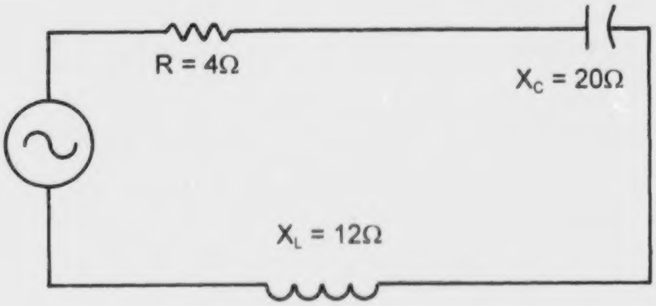


a. Z = ______________

b. X_t = ______________

Assignment Sheet 15

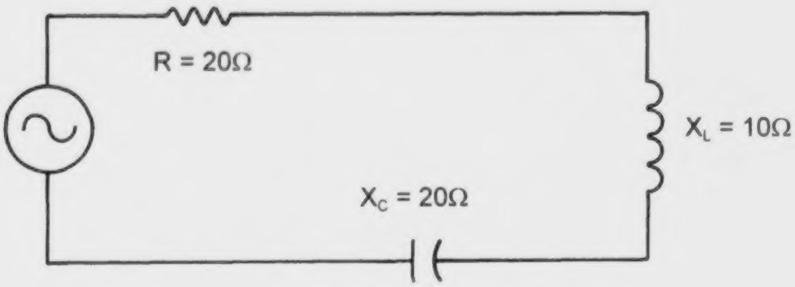
2.


R = 4Ω
X_C = 20Ω
X_L = 12Ω

a. Z = ______________

b. X_t = ______________

3.


R = 20Ω
X_L = 10Ω
X_C = 20Ω

a. Z = ______________

b. X_t = ______________

AC and AC Circuits
Unit 5

Assignment Sheet 16—Solve for Parameters of Resonant Circuits

Name ______________________________ Overall Rating ____________

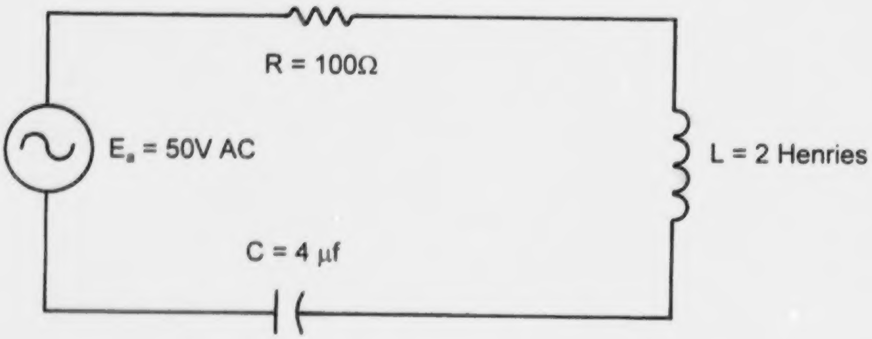
Evaluation criteria	Rating
• Directions have been followed	________
• Minimum of 80 percent of answers are correct	________

Note: Each correct answer is worth 10 points.

Introduction: A resonant circuit is an RCL circuit in which inductance and capacitance are equal. By analyzing a resonant circuit, you will be able to apply all that you have learned about the operation of RCL circuits, and this assignment sheet requires you to analyze such a circuit.

Directions: Study the schematic on the next page and determine the values requested. Write your answers in the spaces provided.

Assignment Sheet 16


R = 100Ω
E_a = 50V AC
L = 2 Henries
C = 4 µf

1. F_R = ____________
2. I_t (at resonance) = ____________
3. X_L = ____________
4. X_C = ____________
5. V_L = ____________
6. V_C = ____________
7. V_R = ____________
8. P = ____________
9. Q = ____________
10. BW = ____________

AC and AC Circuits
Unit 5

Assignment Sheet 17—Solve Problems Related to Parallel RCL Circuits

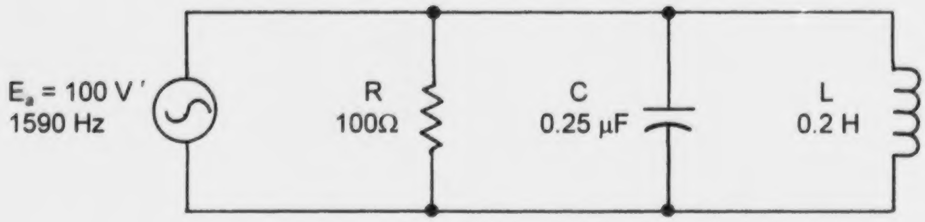
Name ____ Overall Rating ____________

Evaluation criteria	Rating
• Directions have been followed	________
• Minimum of 84 percent of answers are correct	________
Note: Each correct answer is worth 8 points.	

Introduction: The previous assignment sheets have dealt with series AC circuits. However, AC circuits can be wired as parallel circuits, with corresponding effects on the circuit characteristics. In this assignment sheet, you will determine the electrical parameters of a parallel RCL circuit.

Directions: Study the drawing on the next page. Determine the values and sketch the circuits phasor diagram as requested. Write your answers in the spaces provided.

Assignment Sheet 17


E_a = 100 V
1590 Hz
R
100Ω
C
0.25 μF
L
0.2 H

1. X_L = ____________

2. X_C = ____________

3. I_R = ____________

4. I_C = ____________

5. I_L = ____________

6. I_t = ____________

7. Z = ____________

8. P_t = ____________

9. P_a = ____________

10. PF = ____________

11. θ = ____________

AC and AC Circuits
Unit 5

Assignment Sheet 18—Analyze a Parallel Resonant Circuit

Name ____ Overall Rating ____________

Evaluation criteria	Rating
• Directions have been followed	________
• Minimum of 84 percent of answers are correct	________
Note: Each correct answer is worth 4 points.	

Introduction: In the previous assignment sheet, you demonstrated that you can apply formulas to determine the electrical and signal characteristics of a parallel RCL circuit. But the skilled electronics technician is able to do more than just apply formulas to solve for requested values. You must understand what is actually happening in the circuit. This assignment sheet asks you a series of questions to determine whether you have reached this level of understanding and then allows you to demonstrate that understanding by determining the values of electrical and signal characteristics in a parallel resonant circuit.

Directions: This assignment sheet consists of two parts. The first part contains statements about parallel RCL circuits and four possible choices for correctly completing the statements. Complete the statements by writing an "X" beside the correct answer or answers.

Note: Some statements may be correctly completed with more than one of the choices provided.

The second part of the assignment sheet provides a circuit diagram and requests you to determine circuit values. Calculate the values and write your answers on the spaces provided with the drawing.

1. In a parallel circuit, impedance is a function of

_______a. frequency of the voltage applied.

_______b. strength of the voltage applied.

_______c. strength of the induction coil.

_______d. value of the resistor.

Assignment Sheet 18

2. At parallel resonance,

_______a. impedance is at its minimum.

_______b. impedance is at its maximum.

_______c. current is at its minimum.

_______d. current is at its maximum.

3. Frequencies higher than the resonant frequency of a parallel RCL circuit cause more current to be in the

_______a. resistive branch.

_______b. capacitive branch.

_______c. inductive branch.

_______d. series portion of the circuit.

4. Frequencies lower than the resonant frequency of a parallel RCL circuit cause more current to be in the

_______a. resistive branch.

_______b. capacitive branch.

_______c. inductive branch.

_______d. series portion of the circuit.

5. The correct formula for computing resonant frequency is f_R =

_______a. $\frac{1}{RC}$.

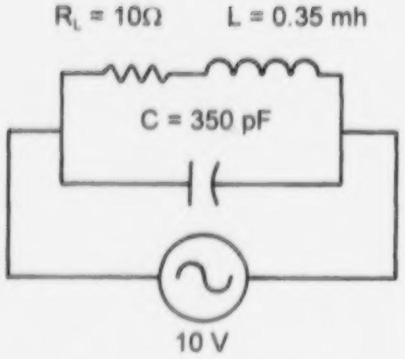
_______b. $\frac{1}{2\pi\sqrt{LC}}$.

_______c. $\frac{1}{2\pi LC}$.

_______d. $\frac{1}{2\pi RC}$.

Assignment Sheet 18

6.


$R_L = 10\Omega$
$L = 0.35$ mh
$C = 350$ pF
10 V

a. $f_R =$ ____________

b. $Q =$ ____________

c. $I_C =$ ____________

d. $I_t =$ ____________

e. $Z =$ ____________

f. $P_t =$ ____________

g. $BW =$ ____________

AC and AC Circuits
Unit 5

Assignment Sheet 19—Calculate the Power in Three-Phase Circuits

Name ______________________________ Overall Rating ____________

Evaluation criteria	Rating
• Directions have been followed	________
• Minimum of 88 percent of answers are correct	________
Note: Each correct answer is worth 12 points.	

Introduction: AC power is normally delivered through the use of three-phase circuits. This configuration introduces a new factor into Watt's Law for calculating power. The normal formula for computing power, P = I x E, must be calculated by the square root of 3 (1.732).

Directions: For each set of three-phase circuit values given below, determine the power of the circuit.

1. 240-volt, 30-amp circuit

   P = __________

2. 120-volt, 10-amp circuit

   P = __________

3. 480-volt, 30-amp circuit

   P = __________

4. 220-volt, 20-amp circuit

   P = __________

5. 250-volt, 15-ampere circuit

   P = __________

AC and AC Circuits
Unit 5

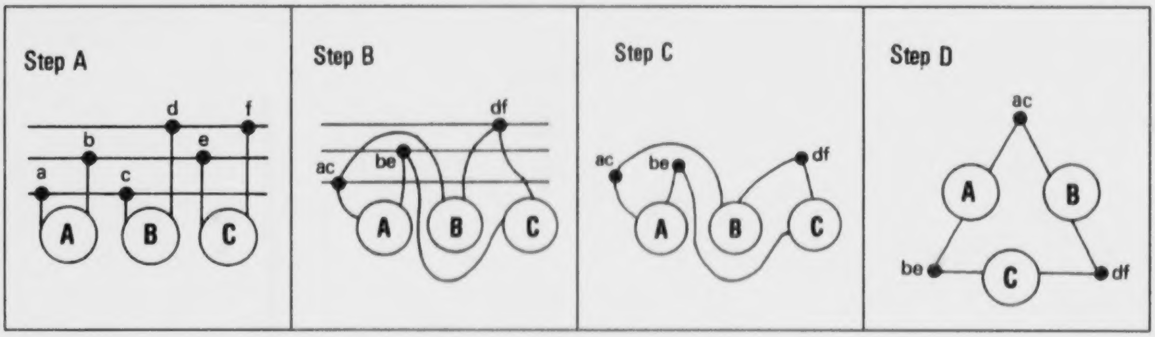
Assignment Sheet 20—Determine Three-Phase Transformer Connections

Name ______________________________ Overall Rating ____________

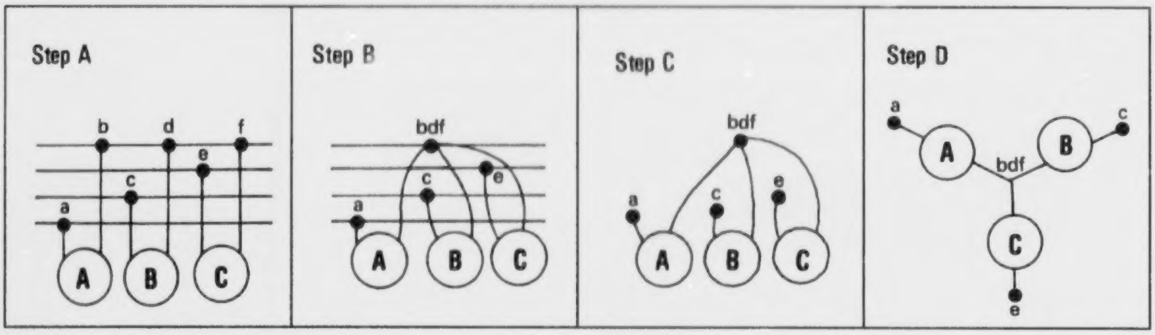
Evaluation criteria	**Rating**
• Directions have been followed	________
• Minimum of 82 percent of answers are correct	________
Note: Each correct answer is worth 18 points.	

Introduction: The connections used for three-phase circuits can be made in a number of ways and may be confusing. This assignment sheet presents a simple method for determining AC three-phase connections and allow you to practice this skill. The procedures for delta-type and wye-type circuits are illustrated below. Note that delta circuits have three wires, while wye circuits have four wires.

Delta Circuit Procedure


Step A
a
b
c
d
e
f
A
B
C
Step B
df
ac
be
A
B
C
Step C
ac
be
df
A
B
C
Step D
ac
A
B
be
C
df

Wye Circuit Procedure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a
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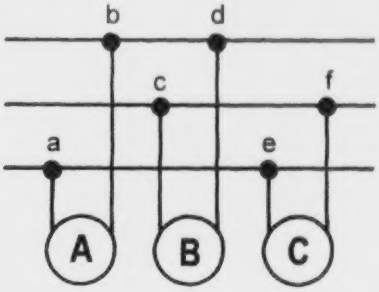
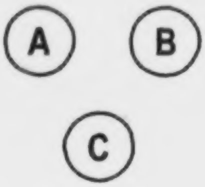
Assignment Sheet 20

Directions: Study the schematics shown below and on the next page. Use the procedure shown in the introduction to this assignment sheet to label the connections in the circuit. Draw the circuit with wye or delta connections and label the terminals as shown in the example on the previous page.

1.





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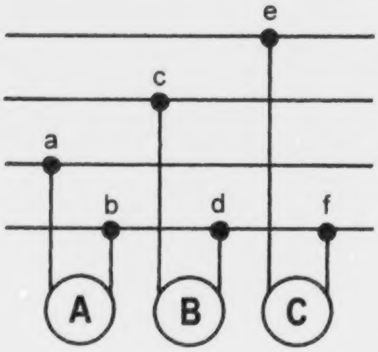

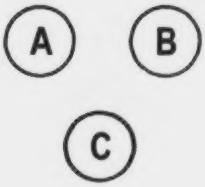

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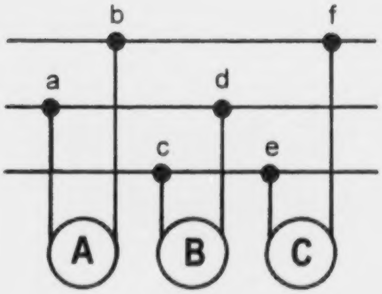
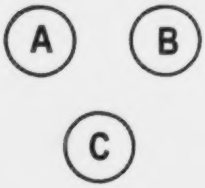
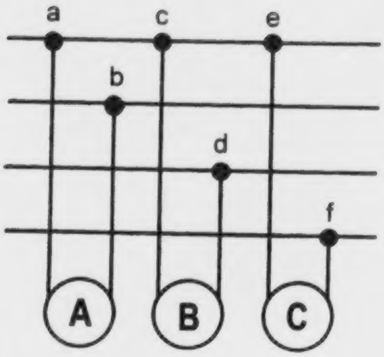
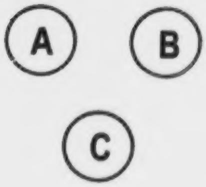




Assignment Sheet 20

4.





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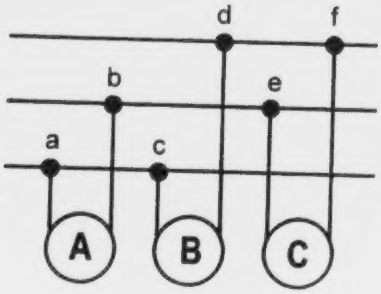

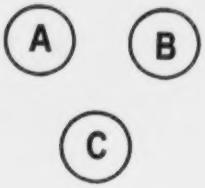

AC and AC Circuits
Unit 5

Job Sheet 1—Measure AC Voltages Using a Multimeter

Name ______________________ Attempt Number __________

Date ______________________ Overall Rating __________

Evaluation criteria	**Rating**
• Procedures were done correctly	________
• Equipment was used correctly	________
• Measurements were accurate	________
• Student demonstrated an understanding of the applicable principles	________

Introduction: In Unit 1, you learned about types of circuits and their electrical characteristics. In Unit 2, you learned about test equipment and how to use it to measure the electrical characteristics of circuits. In the previous unit, you applied those skills to DC circuits. Similar techniques are used with AC circuits. In this first Job Sheet, you will use a multimeter to measure voltages in an AC circuit.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Multimeter
- Work bench with power outlets
- 24-volt transformer
- Test leads
- Pencil and paper

B. Procedure

☐ 1. Set multimeter controls to measure AC voltage.

☐ 2. Connect test leads to multimeter at work bench.

Job Sheet 1

☐ 3. Measure and record voltage between two jack slots in electrical outlet on work bench.

Caution: The voltage in the outlet can cause injury or death. Use care not to touch the metal parts of the test probes when they are in contact with the outlet jacks and do not contact the probes to other metal. Avoid handling both probes or leads at the same time.

☐ 4. Measure and record the voltage between the longer slot in the outlet and the ground slot.

☐ 5. Measure and record the voltage between the shorter slot in the outlet and the ground slot.

☐ 6. Plug transformer into work bench outlet and adjust power to 5 volts.

☐ 7. Measure and record transformer output voltage.

☐ 8. Repeat Steps 6 and 7 for 12 volts.

☐ 9. Repeat Steps 6 and 7 for 18 volts.

☐ 10. Repeat Steps 6 and 7 for 24 volts.

☐ 11. Turn off the transformer and remove it from power.

☐ 12. Discuss your results with your instructor.

Note: Be sure to discuss the voltage reading obtained at Step 4.

☐ 13. Return equipment and materials to their proper storage location.

Evaluator's comments: ______________________________

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AC and AC Circuits
Unit 5

Job Sheet 2—Measure AC Current Using a Multimeter

Name ______________________________ Attempt Number __________

Date ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
• Procedures were done correctly	______
• Equipment was used correctly	______
• Circuit was properly wired	______
• Student demonstrated an understanding of the applicable principles	______

Introduction: A common problem with electronic equipment is that it is operated on faulty AC power. Faulty power can damage electronic components or lead to poor operational performance. Therefore, the electronics technician must be able to determine whether the power source is adequate, such as verifying proper current. This job sheet will provide you with practice in determining AC current characteristics.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- 120-volt lamps of various wattages
- Multimeter
- Test leads
- Work bench with 120-volt power outlets
- 120-volt lamp socket
- Lamp cord with 120-volt plug
- Mounting surface and hardware
- Pencil and paper

B. Procedure

☐ 1. Connect lamp cord in series with socket and multimeter.

☐ 2. Set the multimeter to measure AC amperage.

☐ 3. Install a lamp in the socket.

Job Sheet 2

☐ 4. Apply power to the circuit by plugging the cord into the outlet.

☐ 5. Note and record the amperage; calculate and record the wattage based on the voltage readings obtained in Job Sheet #1.

☐ 6. Unplug the cord and remove the lamp.

Caution: The lamp may be hot. Use a cloth or gloves to avoid burning your fingers.

☐ 7. Repeat Steps 3-6 for all of the remaining lamps except one.

☐ 8. Repeat Steps 3-5 for the last lamp.

☐ 9. Repeat Step 5 at ten-minute intervals for 30 minutes.

Note: You should obtain four readings for the last lamp. It may be necessary to adjust the time interval for the particular configuration and components that you use.

☐ 10. After obtaining the required readings for the last lamp, unplug the cord and remove the lamp.

☐ 11. Discuss the results with your instructor.

☐ 12. Disassemble circuit and return equipment and materials to their proper storage location.

Evaluator's comments: ____________________

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AC and AC Circuits
Unit 5

Job Sheet 3—Determine the Configuration of a Multiple-Winding Transformer

Name ______________________________ Attempt Number __________

Date ______________________________ Overall Rating __________

Evaluation criteria	Rating
• Procedures were done correctly	________
• Equipment was properly connected and operated	________
• Measurements were accurate	________
• Student demonstrated an understanding of the applicable principles	________

Introduction: In this job sheet you will use what you have learned about AC circuitry to analyze the functioning of a transformer. The basic concepts used in this task are similar to what might be required when troubleshooting AC circuitry and will reinforce your understanding of alternating current applications.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Multimeter
- Adjustable DC power supply
- Variable AC power supply
- Multiple winding transformer
- Operator's manual for transformer or wiring diagram
- Test leads
- Pencil and paper
- Wire markers

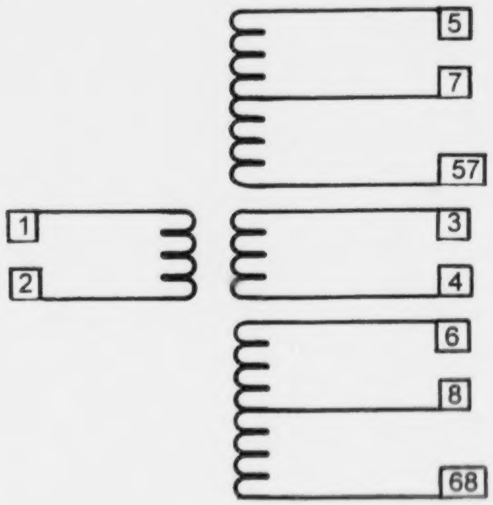
B. Procedure

☐ 1. Using the transformer wiring diagram, label the transformer lead wires with wire markers to show how they are interconnected.

Note: For example, label the primary wires "1" and "2" and secondary wires in groups that show interconnectivity as shown in Figure 1. If necessary, use the multimeter to determine continuity of the wiring.

Job Sheet 3

Figure 1



☐ 2. Connect the AC power supply to the transformer primary leads, but do **not** apply power.

☐ 3. Separate the leads to ensure that the wires do not touch.

☐ 4. Adjust the power supply to its minimum and apply power.

☐ 5. Adjust the power supply to 20 volts.

☐ 6. Measure the voltage between the wires in each group of wires and record your readings.

Note: It may be easier to make a sketch of the windings and label the wires on the sketch.

☐ 7. If any pair of wires reads more than 20 volts, turn off the power supply and remove it from power, then repeat Steps 2-6 with the power supply connected to the wires that showed a reading greater than 20 volts.

☐ 8. Turn off the AC power supply, remove power, and disconnect the power supply.

☐ 9. Set the voltmeter to record voltage and connect it to the two ends of a winding of the transformer.

☐ 10. Set the DC power supply to 24 volts and ensure that the other output lead does not complete a circuit with the lead attached to the transformer.

Job Sheet 3

☐ 11. Apply power to the DC power supply.

☐ 12. Momentarily touch the second lead of the DC power supply to the other transformer primary lead and note the response of the voltmeter, making contact for less than a second and only long enough to observe the voltmeter.

☐ 13. Mark the primary winding positive lead.

Note: A positive needle deflection or a positive flash on a digital meter indicates a live positive circuit. Make a dot on your wiring sketch next to the primary winding wire that is connected to the positive lead of the power supply. A negative needle deflection or negative flash indicates a negative circuit. Make a dot next to the primary winding that is connected to the negative lead of the power supply. These dots are called *phasing dots* and are often indicated on transformer wiring diagrams.

☐ 14. Repeat Steps 9-13 for the other transformer windings.

☐ 15. Remove power from the circuit.

☐ 16. Sketch a wiring diagram of the transformer windings, labeling the positive connections with phasing dots and showing the voltage of the windings.

Note: To determine winding voltage, divide the transformer primary voltage (normally 120 or 240 volts) by the AC power supply input voltage (20 volts per Step 5). This will give you the fractional part of operational voltage. For example, 120 ÷ 20 = 6, so that the measured voltage is only one-sixth of the winding voltage. Multiply your recordings by the computed value to determine the actual ratings for the windings.

☐ 17. Consider the following questions and discuss your results with your instructor.

- Do transformers operate on DC power?
- If AC power changes flow direction constantly, what is the purpose in assigning polarity relationships to the transformer windings?

☐ 18. Disassemble circuit and return equipment and materials to their proper storage location.

Job Sheet 3

Evaluator's comments: ____

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AC and AC Circuits
Unit 5

Job Sheet 4—Test and Replace a Transformer

Name ______________________________ Attempt Number __________

Date ______________________________ Overall Rating __________

Evaluation criteria	Rating
• Procedures were done correctly	______
• Equipment was properly operated	______
• Transformer wiring was correctly identified	______
• Measurements were accurate	______
• Student demonstrated an understanding of the applicable principles	______

Introduction: Transformers are widely used in electronic equipment because of the low power requirements in such equipment and the need for power conditioning. Consequently, the technician must be able to verify the operation of transformers. This includes the identification of the transformer wiring configuration and analysis of equipment operation.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Multimeter
- Multilead transformer
- Test leads
- Masking tape or wire labels
- Pencil and paper

B. Procedure

☐ 1. Determine the primary side of the transformer.

Note: Use a wiring diagram of the transformer if it is available. If not, many transformers use a standard color coding for their wiring. Generally, for transformers without center taps, both primary wires are black. On transformers with center taps, the common wire is black, the tap is black and yellow, and the end wire is black and red. If the leads cannot be identified in this manner, complete Steps 2-7 to identify the wiring. If the wiring has been identified, proceed to Step 8.

Job Sheet 4

☐ 2. If the wiring has not been identified, then tag each wire and label it with a letter.

☐ 3. Make a sketch of a transformer schematic to include the number of winding leads found in the transformer being tested.

☐ 4. Set the multimeter for use as an ohmmeter and, starting with wire A, check wire A and one other wire for low resistance with the common lead connected to wire A and the red lead connected to a second wire.

☐ 5. Repeat Step 4 until the low resistance pair is determined.

☐ 6. Label the wires on your schematic to show the position of the wires that produced the low resistance reading.

☐ 7. Repeat Steps 4-6 until all the wires on the schematic have been identified and then go to Step 9.

Note: If one or more leads cannot be identified, an open condition probably exists in the wiring and should be identified as a defect with the transformer.

☐ 8. Check the transformer for opens by using the multimeter configured as an ohmmeter to verify a low resistance reading across each circuit.

☐ 9. Check the transformer for shorts by connecting the common multimeter lead to the core and the red multimeter lead to each transformer lead.

☐ 10. Remove power from the equipment.

☐ 11. Return equipment and materials to their proper storage location.

Evaluator's comments: ____

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AC and AC Circuits
Unit 5

Job Sheet 5—Show the Effect of Inductance in AC Circuits

Name ______________________________ Attempt Number __________

Date ______________________________ Overall Rating ___________

Evaluation criteria	**Rating**
• Procedures were done correctly	______
• Circuit was properly wired	______
• Measurements were accurate	______
• Student demonstrated an understanding of the applicable principles	______

Introduction: In electronic circuitry, inductance, impedance, and reactance values can play significant roles. Therefore, the electronics technician must be able to determine expected values for these characteristics and analyze circuits to determine actual values. You will practice these tasks in this unit, beginning with inductance in this job sheet.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Multimeter capable of measuring DC and AC milliamperes (or equivalent meters)
- DC power supply
- AC power supply
- 75- ohm 1-watt resistor
- 2-H or larger filter choke inductor
- Low-voltage conductor
- Mounting surface and hardware
- Pencil and paper

B. Procedure

☐ 1. Set the multimeter to read DC milliamperes and connect it in series with the DC power supply and resistor.

☐ 2. Energize the circuit and adjust the power supply to 5 volts.

☐ 3. Measure and record the amperage.

Job Sheet 5

☐ 4. Compute the resistance for the DC circuit and record it as R_{DC}.

☐ 5. Remove power from the circuit and repeat Steps 1-3 with the AC power supply.

☐ 6. Compute the resistance for the AC circuit and record it as R_{AC}.

☐ 7. Compare the two resistance values and write your explanation for any difference that may be noted.

☐ 8. Remove power from the circuit.

☐ 9. Remove the resistor and replace it with the filter choke.

☐ 10. Energize the circuit and adjust the power supply to 5 volts.

☐ 11. Measure and record the amperage.

☐ 12. Compute the impedance for the AC circuit and record it as Z_{AC}.

☐ 13. Remove power from the circuit.

☐ 14. Replace the AC power supply with the DC power supply.

☐ 15. Repeat Steps 10 and 11.

☐ 16. Compute the impedance for the DC circuit and record it as Z_{DC}.

☐ 17. Compare the two current values from Steps 11 and 15 and write your explanation for any difference that may be noted.

☐ 18. Compute the inductance values for the AC circuits.

☐ 19. Compare the two impedance values and write your explanation for any difference that may be noted.

☐ 20. Disassemble circuit and return equipment and materials to their proper storage location.

Evaluator's comments: ____

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AC and AC Circuits
Unit 5

Job Sheet 6—Solve for Values of an Operating RL Circuit

Name ______________________________ Attempt Number __________

Date ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
• Procedures were done correctly	________
• Circuit was properly wired	________
• Measurements were accurate	________
• Student demonstrated an understanding of the applicable principles	________

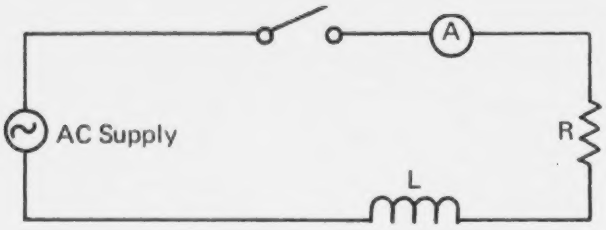
Introduction: This unit has covered some of the more common AC circuits used in electronics equipment and has explained how the resistance, capacitance, and inductance characteristics affect the operation of a circuit and its electrical characteristics. This information has been largely theoretical for you to this point. However, beginning with this job sheet, you will explore the operation of actual AC circuits with various electrical characteristics, starting with an RL circuit.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Multimeter
- AC power supply
- One filter choke inductor, 2H or more
- One 750 ohm resistor, 5 watts or more
- AC ammeter
- SPST switch
- Low-voltage conductor
- Mounting surface and hardware
- Pencil and paper
- Graph paper
- Circuit drawing on next page

Job Sheet 6



B. Procedure

☐ 1. Configure the multimeter as an ohmmeter and measure the resistance of the inductor; record this value as R_L.

☐ 2. Measure and record the value of the resistor as R.

☐ 3. Assemble circuit per drawing, but do **not** apply power.

☐ 4. Set the multimeter to function as an AC voltmeter and connect it across the power supply.

☐ 5. Energize the circuit and adjust the AC power supply until the multimeter shows 30 volts.

☐ 6. Read voltage across the resistor and record it as E_R.

☐ 7. Read voltage across the inductor and record it as E_L.

☐ 8. Read the applied voltage and record it as E_a.

☐ 9. Set the multimeter to read AC current.

☐ 10. Read the circuit current and record it as I.

☐ 11. Compute and record the value of X_L.

☐ 12. Compute the circuit's voltage using Ohm's Law and the values R, X_L, and I and record it as E_{a1}.

☐ 13. Compare E_{a1} to E_a measured in Step 8.

☐ 14. Add E_R and E_L and record this value as E_{a2}.

☐ 15. Compare E_{a2} to E_a and E_{a1}.

Job Sheet 6

☐ 16. Compute E_a using the formula below and record the value as E_{a3}:

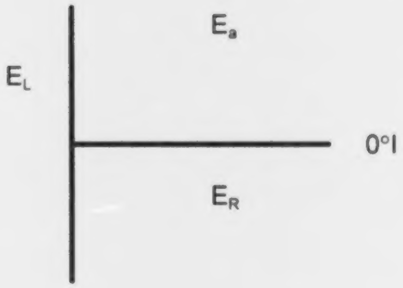
$$E_a = \sqrt{E_R^2 + E_L^2}$$

☐ 17. Multiply I by X_L and record this value as E_{L1}.

☐ 18. Compare E_L and E_{L1}.

☐ 19. Use the graph paper to make a vector diagram of the applied voltage based on E_L and E_R following the example shown below.

Figure 1



☐ 20. Discuss your results with your instructor; be prepared to discuss the following points:

- What could lead to the differences in the applied voltage values (if any) between the measured value and the various calculations?
- If there were differences, which of the calculated values was nearest to the measured value and why might this be?
- What would happen to X_L if the circuit were constructed with a 1H filter choke inductor instead of a 2H inductor?
- What would happen to X_L if the circuit were constructed with a 1000-ohm resistor instead of a 750-ohm resistor?

☐ 21. Remove power from the circuit.

☐ 22. Disassemble circuit and return equipment and materials to their proper storage location.

Job Sheet 6

Evaluator's comments: ______________________________

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AC and AC Circuits
Unit 5

Job Sheet 7—Test Capacitors with an Ohmmeter

Name ______________________ Attempt Number __________

Date ______________________ Overall Rating __________

Evaluation criteria	**Rating**
• Procedure was done correctly	______
• Equipment was used correctly	______
• Capacitor status was correctly identified	______

Introduction: There are basically three electrical problems that can occur internal to a capacitor:

- the capacitor can be shorted
- the capacitor can be open
- the capacitor can be leaking

Each of these conditions can be revealed by checking the capacitor with an ohmmeter or multimeter set up as an ohmmeter. When touched to the leads of the capacitor, the ohmmeter will send current through the capacitor. A functioning capacitor will build up a charge as the current goes through it, though for small capacitors the charge time is very short. This is indicated by a "slow" change in the ohmmeter reading as it increases toward ∞ as the capacitor becomes fully charged. However, if the capacitor is shorted, current flows but does not build up a charge on the capacitor plates. This is indicated by a reading at or near 0 on the ohmmeter. If there is an open condition in the capacitor, current will not flow through it, resulting in an immediate ∞ reading. Finally, if the capacitor is leaking, the charge build-up will be slower and will never allow the ohmmeter to reach ∞.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Note: Prior to performing this procedure, ensure that your instructor has demonstrated the ohmmeter response of a known-good capacitor. If not already done, ask your instructor to demonstrate the response before beginning this procedure.

Job Sheet 7

A. Equipment and materials

- Ohmmeter or multimeter
- Test leads
- Capacitors supplied by your instructor
- Paper and pencil

B. Procedure

☐ 1. Select the capacitor to be tested.

☐ 2. With the multimeter set to measure resistance, touch one probe of the multimeter to one of the capacitor leads.

☐ 3. Touch the other probe to the other lead.

☐ 4. Check the multimeter and observe the reading and behavior of the needle.

☐ 5. Continue to monitor the meter until the reading is 0, ∞, or there is no longer any needle movement toward ∞.

☐ 6. Classify the capacitor as good, shorted, open, or leaking and record your results.

☐ 7. Repeat Steps 1-6 for the remaining capacitors.

☐ 8. Return equipment and materials to their proper storage location.

Evaluator's comments: ____

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AC and AC Circuits
Unit 5

Job Sheet 8—Determine the Effect of AC and DC on Capacitors

Name ______________________ Attempt Number __________

Date ______________________ Overall Rating __________

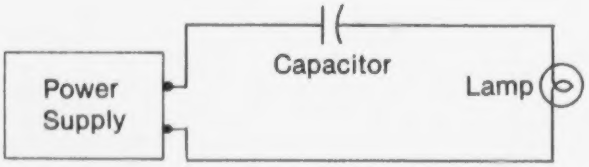
Evaluation criteria	Rating
• Equipment was set up correctly	______
• Correct procedures were followed	______
• Circuit was correctly wired	______
• Student demonstrated an understanding of the applicable principles	______

Introduction: Capacitors are important components in electronic equipment. Therefore, the electronics technician must understand the operation of these components under various conditions. In this job sheet, you will examine the effects of direct current versus alternating current on capacitor operation.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Miniature lamp
- Lamp socket
- AC power supply, 0-40 volts
- DC power supply, 0-40 volts
- One 10 μF, 100-watt or two 5 μF, 100-watt electrolytic capacitor(s)
- Low-voltage conductor
- Mounting surface and hardware
- Pencil and paper
- Circuit drawing



Job Sheet 8

B. Procedure

☐ 1. Assemble circuit per drawing using the DC power supply, but do **not** apply power.

☐ 2. Energize the circuit and adjust the power supply to 20 volts.

☐ 3. Observe whether the lamp illuminates.

☐ 4. Turn off the power supply and remove power from the circuit.

☐ 5. Replace the DC power supply with the AC power supply.

☐ 6. Repeat Steps 2-4.

☐ 7. Discuss the results with your instructor; be prepared to discuss the following points:

- What function does the capacitor serve in the circuit?
- What is the voltage drop across the capacitor when DC power is applied?
- What is the voltage drop across the capacitor when AC power is applied?
- Considering the observed effects, suggest a use for capacitors in electronic circuits that can make use of this effect.

☐ 8. Remove power from the circuit.

☐ 9. Disassemble circuit and return equipment and materials to their proper storage location.

Evaluator's comments: ____

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AC and AC Circuits
Unit 5

Job Sheet 9—Determine Time Constants of RC Circuits

Name ______________________ Attempt Number ____________

Date ______________________ Overall Rating ____________

Evaluation criteria	Rating
• Equipment was set up correctly	________
• Correct procedures were followed	________
• Circuit was correctly wired	________
• Student demonstrated an understanding of the applicable principles	________

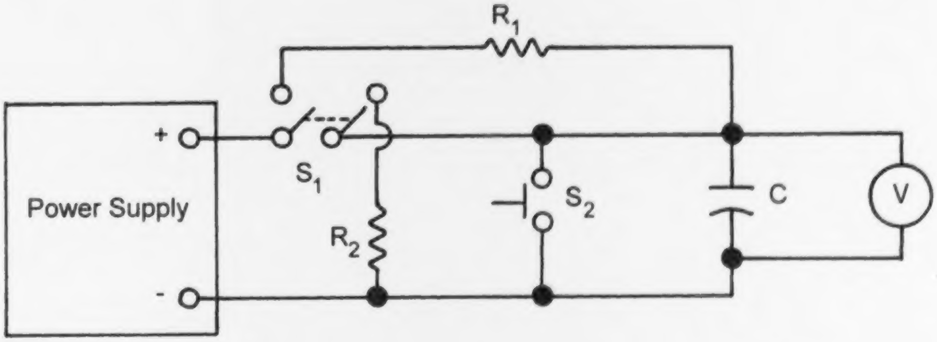
Introduction: The fact that electronic components function in accordance with certain constants is very helpful in making such devices useful. Such constants allow technicians and engineers to be able to predict circuit performance when servicing and designing electronic circuits. One of the most useful constants is the time constant that governs the charging and discharging of capacitors as discussed in the information sheet. This job sheet will allow you to verify the time constant and to observe its effects under operational conditions.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- DC power supply, 0-20 volts
- Multimeter or voltmeter
- Test leads
- One 100 Kohm resistor, 1 watt
- One 470 Kohm resistor, 1 watt
- One 1 Mohm resistor, 1 watt
- One 2.2 Mohm resistor, 1 watt
- Two 10 μF electrolytic capacitors, more than 20 volts
- DPDT switch
- Normally open pushbutton switch
- Low-voltage conductor
- Mounting surface and hardware
- Stopwatch or clock with second hand
- Pencil and paper
- Table at end of job sheet
- Circuit drawing on next page

Job Sheet 9



B. Procedure

☐ 1. Assemble the circuit per the drawing, using the 100-Kohm resistor for R_1 and the 470-Kohm resistor for R_2 and one of the capacitors and with the switches both open; do **not** apply power to the circuit.

☐ 2. Calculate the capacitor time constant and charge/discharge times (5 times time constant) and record them in the table at the end of the job sheet.

☐ 3. Energize the circuit and adjust the power supply to 15 volts.

☐ 4. Position yourself to observe the stopwatch and the voltmeter and be prepared to start timing how long it takes for the voltmeter to reach 15 volts once the DPDT switch is closed.

☐ 5. Close the DPDT and begin timing the charging process.

☐ 6. Once the voltmeter reads 15 volts, stop the stopwatch and open the DPDT to prevent further charging.

☐ 7. Record the observed charging time.

☐ 8. Reset the stopwatch and be prepared to time the discharge rate once the pushbutton switch is closed.

☐ 9. Hold the pushbutton switch closed and time the discharge of the capacitor until the voltmeter reads zero.

☐ 10. Release the pushbutton and record the discharge time.

☐ 11. Remove power from the circuit.

Job Sheet 9

☐ 12. Replace R_1 with the 1-Mohm resistor and R_2 with the 2.2-Mohm resistor.

☐ 13. Repeat Steps 2-11 for this configuration.

☐ 14. Replace R_1 with the 2.2-Mohm resistor and R_2 with the 470-Kohm resistor and add the second capacitor in series with the first.

☐ 15. Repeat Steps 2-11 for this configuration.

☐ 16. Replace R_1 with the 1-Mohm resistor and R_2 with the 100-Kohm resistor and wire the second capacitor parallel with the first.

☐ 17. Repeat Steps 2-11 for this configuration.

☐ 18. Discuss your results with your instructor; be prepared to discuss the following points:

- What is the function of each branch of the circuit in the initial configuration?
- What could lead to differences (if any) between calculated and observed time constants and total times?
- What is the impact of switching the resistor values?
- What is the impact of adding a second capacitor in series?
- What is the impact of adding a second capacitor in parallel?

☐ 19. Disassemble circuit and return equipment and materials to their proper storage location.

Evaluator's comments: ______________________________

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Job Sheet 9

Configuration	Calculated Constant	Calculated Time	Observed Charge Time	Observed Discharge Time
1				
2				
3				
4				

Notes:

AC and AC Circuits
Unit 5

Job Sheet 10—Construct a Neon Bulb Flasher

Name ______________________________ Attempt Number __________

Date ______________________________ Overall Rating ____________

Evaluation criteria	**Rating**
• Procedure was done correctly	________
• Equipment was used correctly	________
• Circuit was correctly wired	________
• Student demonstrated an understanding of the applicable principles	________

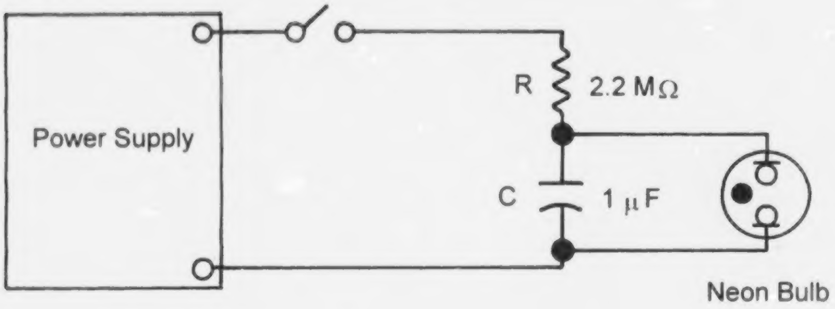
Introduction: In this job sheet you will build and operate an RC circuit and observe the effects of changing elements in the circuit. The circuit uses a neon lamp as its load and is, thus, essentially a pure RC circuit to help clarify the role of each component in the circuit. Frequently, subcircuits in electronic equipment will be simple RC circuits, so that this procedure will be directly applicable to equipment configurations on which you will work as an electronics technician.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- DC power supply, 0-100 volts
- Neon bulb
- Socket for bulb
- One 1 Mohm resistor, 1 watt
- Two 2.2 Mohm resistors
- Two 1 μF electrolytic capacitors, more than 100 volts
- SPST switch
- Low-voltage conductor
- Mounting surface and hardware
- Pencil and paper
- Graph paper
- Stopwatch or clock with second hand
- Circuit drawing on next page

Job Sheet 10



B. Procedure

☐ 1. Assemble circuit per drawing with the switch open, but do **not** apply power.

☐ 2. Energize the circuit and adjust the power supply to 100 volts.

☐ 3. Close the switch and observe the lamp.

☐ 4. Open the switch and remove power from the circuit.

☐ 5. Add the second resistor in series with the first.

☐ 6. Repeat Steps 2-4.

☐ 7. Remove one of the resistors.

☐ 8. Add the second capacitor to the circuit in parallel with the first.

☐ 9. Close the switch and observe the lamp.

☐ 10. Time the light pulses to determine how long the lamp is lit and how long it is off.

☐ 11. Remove power from the circuit after timing at least three cycles of the lamp illuminating and dimming.

☐ 12. Make a graph of the lamp pulses, showing voltage on the vertical axis and time on the horizontal axis.

Note: You may either monitor the voltage in the circuit or assume that the lamp starts with a voltage of 70 volts and will continue to be driven on as long as the voltage remains above 40 volts.

Job Sheet 10

☐ 13. Discuss your results with your instructor; be prepared to discuss the following points:

- Describe the role of each component in the original circuit and in each of the modified configurations.
- What is the effect of increasing resistance?
- What is the effect of increasing capacitance?
- Would the circuit behave differently if the second resistor had been inserted as a parallel component?
- Would the circuit behave differently if the second capacitor had been inserted as a series component?

☐ 14. Return equipment and materials to their proper storage location.

Evaluator's comments: ____

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AC and AC Circuits
Unit 5

Job Sheet 11—Show the Effect of Capacitive Reactance in AC Circuits

Name ______________________________ Attempt Number __________

Date ______________________________ Overall Rating ____________

Evaluation criteria	**Rating**
• Procedure was done correctly	________
• Equipment was used correctly	________
• Circuit was correctly wired	________
• Student demonstrated an understanding of the applicable principles	________

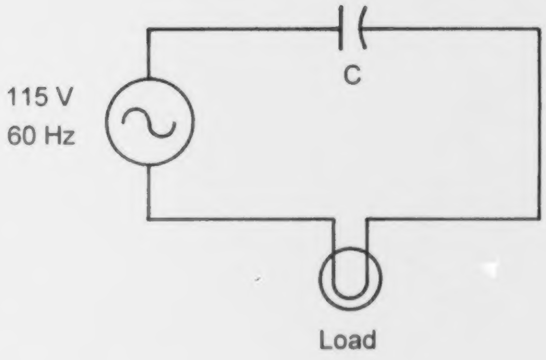
Introduction: Capacitive reactance is a function of frequency and capacitance. You have learned the formula for computing its theoretical value. In this job sheet, you will build an RC circuit and determine the effects of varying capacitance values. This will not only strengthen your understanding of capacitive reactance, it will also provide you with some idea of the effects of a defective capacitor in a circuit.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- AC power supply, 60 Hz
- One 15-watt light bulb
- Socket for bulb
- One 8 μF capacitor, 450 watts
- One 1 μF capacitor, 450 watts
- Low-voltage conductor
- Mounting surface and hardware
- Pencil and paper
- Circuit drawing on the next page

Job Sheet 11



B. Procedure

☐ 1. Assemble circuit per drawing using the 8 µF capacitor, but do **not** apply power.

☐ 2. Energize the circuit and observe the brightness of the bulb.

☐ 3. Measure and record E_a.

☐ 4. Measure and record E_C.

☐ 5. Measure and record E_L.

☐ 6. Compute capacitive reactance using the formula:

$$X_C = \frac{1}{2\pi fC}$$

☐ 7. Compute E_a using the formula:

$$E_a = \sqrt{E_R^2 + E_L^2}$$

☐ 8. Remove power from the circuit.

☐ 9. Remove the capacitor and replace it with the 1 µF capacitor.

☐ 10. Repeat Steps 2-8.

Job Sheet 11

☐ 11. Discuss your results with your instructor; be prepared to discuss the following points:

- What is the role of each component in the circuit?
- What is the effect on capacitive reactance on changing the capacitor?
- How did the operation of the bulb change when the capacitor was changed?
- If there was a difference between computed and measured E_a, what could account for this difference?
- What would be the impact on capacitive reactance if a 30 Hz power supply were used?

☐ 12. Return equipment and materials to their proper storage location.

Evaluator's comments: ____

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AC and AC Circuits
Unit 5

Job Sheet 12—Determine Capacitive Reactance and Impedance in RC Circuits

Name ______________________________ Attempt Number __________

Date ______________________________ Overall Rating ____________

Evaluation criteria	**Rating**
• Procedure was done correctly	________
• Equipment was used correctly	________
• Circuit was correctly wired	________
• Student demonstrated an understanding of the applicable principles	________

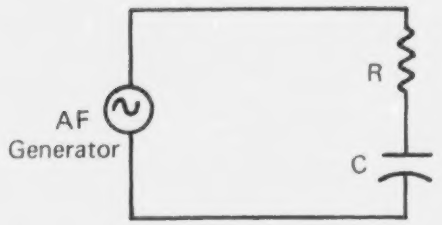
Introduction: In the previous job sheet, you examined the effects on capacitive reactance of varying circuit capacitance. But you also considered the fact that capacitive reactance is a function of frequency. Manipulation of frequency values is one of the most useful operations in electronic equipment because of the use of electrical current as signals. In this job sheet, you will use a simple RC circuit to examine the effects of varying frequencies on such electrical characteristics as capacitive reactance, impedance, and power factors.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Audio frequency generator
- Multimeter
- Test leads
- One 1 Kohm resistor, 1 watt
- One 0.3 μF capacitor
- Low-voltage conductor
- Mounting surface and hardware
- Pencil and paper
- Graph paper
- Protractor
- Table at end of this job sheet
- Circuit drawing on next page

Job Sheet 12



B. Procedure

☐ 1. Assemble circuit per drawing, but do **not** apply power.

☐ 2. Energize the circuit and set the frequency generator to 150 Hz with an output of 1 volt.

☐ 3. Measure E_R and record the value in the table.

☐ 4. Measure E_C and record the value in the table.

☐ 5. Repeat Steps 2-4 for each frequency listed in the table.

☐ 6. Using the formula

$$X_C = \frac{1}{2\pi f C},$$

calculate the frequency that would be required to produce a capacitive reactance of 1000 ohms and enter this value in the last row of the first column of the table.

☐ 7. Repeat Steps 2-4 using the frequency value calculated in Step 6.

☐ 8. Remove power from the circuit.

☐ 9. Compute the current for each frequency and enter the values in the I column of the table; use the formula:

$I = \frac{E_R}{R}$, and assume that R is 1000 ohms.

Job Sheet 12

☐ 10. Compute the impedance for each frequency and enter the values in the $\mathbf{Z}^1$ column of the table; use the formula:

$$Z = \frac{E_a}{I}$$

☐ 11. Compute the capacitive reactance for each frequency and enter the values in the $\mathbf{X_C}^1$ column of the table; use the formula:

$$X_C = \frac{1}{2\pi fC}$$

☐ 12. Compute the capacitive reactance for each frequency and enter the values in the $\mathbf{X_C}^2$ column of the table; use the formula:

$$X_C = \frac{E_C}{I}$$

☐ 13. Make a vector graph to determine impedance by plotting X_C from Step 12 on the y-axis and R on the x-axis so that the vector of the coordinates is Z; use this procedure for each frequency.

☐ 14. Use the protractor to measure the phase angle on the graph and enter this value in the θ^1 column.

☐ 15. Compute the phase angle for each frequency and enter the values in the θ^2 column of the table; use the formula:

$$\theta = \arccos \frac{E_R}{E_a}$$

☐ 16. Compute the power factor for each frequency and enter the values in the **PF** column of the table; use the formula:

$$PF = \cos \theta$$

☐ 17. Discuss your results with your instructor; be prepared to discuss the following points:

- What could account for any differences observed in the computed values for X_C, Z, and the phase angles?
- What is the general trends for each value as the frequency is increased?

- Because it is generally easier to control capacitance than frequency in a circuit, how would you address the requirement to have an X_C of 1000 ohms if you were designing this circuit?

☐ 18. Return equipment and materials to their proper storage location.

Evaluator's comments: ____

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Job Sheet 12

Data Table

Freq. (Hz)	E_R	E_C	I	Z^1	X_C^1	X_C^2	Z^2	θ^1	θ^2	PF
150										
250										
450										
900										
1100										
				1000						

Notes:

AC and AC Circuits
Unit 5

Job Sheet 13—Determine Resonance in a Series RCL Circuit

Name ______________________ Attempt Number __________

Date ______________________ Overall Rating __________

Evaluation criteria	**Rating**
• Procedure was done correctly	________
• Equipment was used correctly	________
• Circuit was correctly wired	________
• Student demonstrated an understanding of the applicable principles	________

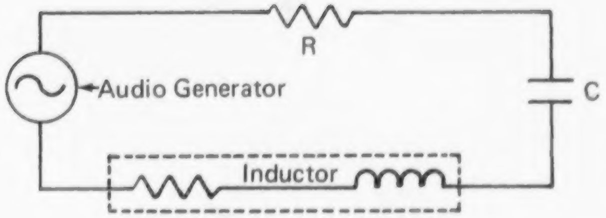
Introduction: As electronic circuits become more complex, they are harder to classify in simple terms of resistive, capacitive, inductive, or similar type circuits. In fact, some circuits may exhibit characteristics of one type of circuit under certain conditions and as another type of circuit when the conditions change. The skilled electronics technician understands the factors that influence circuit operation and is able to use that knowledge to predict how circuits should perform and to analyze whether a circuit is operating per those predictions. One of the types of circuits that the technician is likely to encounter is the RCL circuit. This job sheet allows you to practice working with RCL circuits.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Audio frequency generator
- Multimeter
- Oscilloscope
- Test leads
- One 1 H inductor
- One 100 ohm resistor
- One 1 μF capacitor
- Low-voltage conductor
- Mounting surface and hardware
- Pencil and paper
- Graph paper
- Protractor
- Table at end of this job sheet
- Circuit drawing on the next page

Job Sheet 13



B. Procedure

☐ 1. With the multimeter configured as an ohmmeter, measure the resistance of the resistor and record it in the table as $\mathbf{R_1}$.

☐ 2. With the multimeter configured as an ohmmeter, measure the resistance of the inductor and record it in the table as $\mathbf{R_L}$.

☐ 3. Assemble circuit per drawing, but do **not** apply power.

☐ 4. Compute the resonant frequency for the circuit and record it in the table as $\mathbf{f_r}$.

☐ 5. Energize the circuit.

☐ 6. Set the multimeter to measure voltage and connect it across the generator output terminals.

☐ 7. Set the audio generator to produce maximum voltage at 100 Hz.

☐ 8. Adjust the audio generator frequency around the computed resonant frequency until the lowest voltage output is noted and record the value in the table as $\mathbf{E_{out}}$.

☐ 9. Adjust the audio generator voltage setting to a level approximately 5 percent less than E_{out} and record this value as $\mathbf{E_a}$.

☐ 10. Remove the multimeter from the audio generator and replace it with the oscilloscope.

☐ 11. Verify the voltage on the oscilloscope and maintain this reading through the remaining powered steps of this procedure.

☐ 12. Connect the multimeter across the resistor.

☐ 13. Verify E_a and then note the voltage drop across the resistor; record this value as $\mathbf{V_{prime}}$.

Job Sheet 13

☐ 14. Adjust the audio frequency output to 80 Hz.

☐ 15. Verify E_a and then note the voltage drop across the resistor; record this value under $\mathbf{V_R}$.

☐ 16. Repeat Steps 14 and 15 for the remaining frequencies in the table.

☐ 17. Determine from the readings taken which frequency gives the greatest voltage drop across the resistor and record the value as $\mathbf{f_0}$.

☐ 18. Adjust the audio generator to the frequency determined in Step 17.

☐ 19. Remove the multimeter from the resistor.

☐ 20. Verify E_a and then connect the oscilloscope to the resistor.

☐ 21. Adjust the oscilloscope for proper display of the waveform and note the wave amplitude and bandwidth; record these values as $\mathbf{R_{amp}}$ and $\mathbf{R_{BW}}$ respectively under the **Resonant Frequency** column.

☐ 22. Move the leads in sequence and connect the oscilloscope to the capacitor.

☐ 23. Adjust the oscilloscope for proper display of the waveform and note the wave amplitude and bandwidth; record these values as $\mathbf{C_{amp}}$ and $\mathbf{C_{BW}}$ respectively under the **Resonant Frequency** column.

☐ 24. Move the leads in sequence and connect the oscilloscope to the inductor.

☐ 25. Adjust the oscilloscope for proper display of the waveform and note the wave amplitude and bandwidth; record these values as $\mathbf{L_{amp}}$ and $\mathbf{L_{BW}}$ respectively under the **Resonant Frequency** column.

☐ 26. Adjust the generator to 100 Hz.

☐ 27. Repeat Steps 20-25 for the new setting and record the values under the **100 Hz** column.

☐ 28. Remove power from the circuit.

☐ 29. Compute the current for each frequency and enter the values in the **I** column of the table; use the formula:

$$I = \frac{V_R}{R}$$

Job Sheet 13

☐ 30. Compute the impedance for each frequency and enter the values in the **Z** column of the table; use the formula:

$$Z = \frac{E_a}{I}$$

☐ 31. Prepare a graph with the frequencies, including f_r, along the x-axis and current values along the y-axis, completing the graph by connecting the readings with a smooth curve.

☐ 32. Plot the values for Z on the same graph with impedance values shown on the y-axis, completing the graph by connecting the readings with a smooth curve.

☐ 33. Discuss your results with your instructor; be prepared to discuss the following points:

- If there was a difference in the calculated and observed resonant frequencies, what could account for this difference?
- At Step 8, why was the voltage adjusted to a minimum level?
- What is the correlation between current and impedance as the frequency varied?
- With regard to the lowest impedance value, how does it compare to the measured values of the resistor and inductance; is this relationship expected?
- Once the circuit was set to the resonant frequency, was there a large difference between the capacitor voltage (Step 23) and the inductor voltage (Step 25)? Why or why not?
- What was the phase relationship between the capacitor voltage (Step 23) and the inductor voltage (Step 25)?
- Once the circuit was set to 100, was there a large difference between the capacitor voltage and the inductor voltage (Step 27)? Why or why not?
- What was the phase relationship between the capacitor voltage and the inductor voltage (Step 27)?
- If this circuit were connected between a generator and a load, what frequency would pass through the circuit most easily? What would be the impedance at that frequency? What would be the impedance of a frequency 80 Hz greater? 80 Hz less?

Job Sheet 13

☐ 34. Return equipment and materials to their proper storage location.

Evaluator's comments: ____

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Job Sheet 13

Data Table

General Values

R_1	
R_L	
f_r	
f_o	
E_{out}	
E_a	
V_{prime}	

Frequency Measurements and Calculations

Frequency (Hz)	V_R	I	Z
80			
100			
120			
140			
160			
180			
200			
220			
240			

Job Sheet 13

Oscilloscope Readings

	Resonant Frequency	100 Hz
R_{amp}		
R_{BW}		
C_{amp}		
C_{BW}		
L_{amp}		
L_{BW}		

Notes:

AC and AC Circuits
Unit 5

Job Sheet 14—Determine the Resonant Frequency of an RCL Parallel Circuit

Name ______________________________ Attempt Number __________

Date ______________________________ Overall Rating __________

Evaluation criteria	**Rating**
• Procedure was done correctly	______
• Equipment was used correctly	______
• Circuit was correctly wired	______
• Student demonstrated an understanding of the applicable principles	______

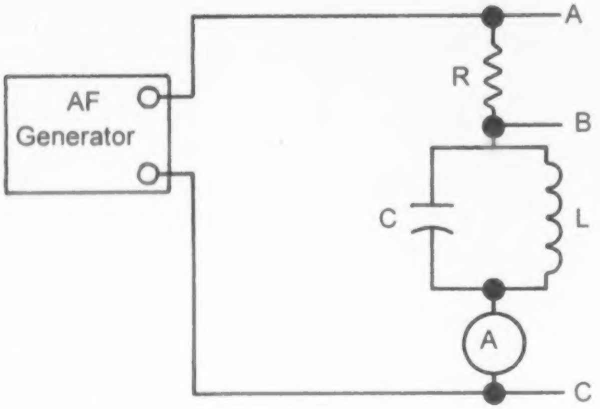
Introduction: In the previous job sheet, you examined the effects of frequency changes in a series RCL circuit and determined the resonant frequency for such a circuit. In this job sheet, similar principles will be used to determine the resonant frequency of a parallel RCL circuit. After the detail with which you examined the series circuit and with your understanding of electrical circuitry, you should be in a good position to predict what you will observe with the parallel RCL circuit. Consider the points examined in the previous job sheet and decide how your answers might differ for a parallel circuit.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- Audio frequency generator
- Multimeter
- Ammeter, 0-150 μA
- Test leads
- One 10 mH inductor
- One 10 Kohm resistor, 1 watt
- One 0.001 μF capacitor
- Low-voltage conductor
- Mounting surface and hardware
- Pencil and paper
- Graph paper
- Protractor
- Table at end of this job sheet
- Circuit drawing on next page

Job Sheet 14



B. Procedure

☐ 1. Calculate the resonant frequency of the circuit and record it as **f_r** in the table.

☐ 2. Assemble circuit per drawing and energize the circuit.

☐ 3. Adjust the frequency generator to f_r and maximum voltage output.

☐ 4. Check the multimeter and observe the reading and behavior of the needle.

☐ 5. Set the multimeter to check AC voltage in a 5-volt range.

☐ 6. Connect the multimeter to read across the tank circuit with the common lead connected at point C.

☐ 7. Adjust the frequency setting up and down to obtain the maximum voltage reading and minimum ammeter reading.

☐ 8. Note the frequency setting and record it as **f_r** in the table.

☐ 9. Adjust the generator for a voltage reading of 1 volt.

☐ 10. Measure the voltage drop across the capacitor and record this value as **V_C** in the table.

☐ 11. Enter the ammeter reading in the table as **I_t**.

☐ 12. Adjust the frequency for 10 kHz above the resonant frequency.

Job Sheet 14

☐ 13. Repeat Steps 9-11 for the new frequency.

☐ 14. Repeat Steps 12 and 13 for each remaining frequency listed in the table.

☐ 15. Calculate the inductive reactance for the resonant frequency and enter this value as $\mathbf{X}_L$ in the table.

☐ 16. Calculate the capacitive reactance for the resonant frequency and enter this value as $\mathbf{X}_C$ in the table.

☐ 17. Calculate the current across the inductor and enter this value as $\mathbf{I}_L$ in the table.

☐ 18. Calculate the current across the capacitor and enter this value as $\mathbf{I}_C$ in the table.

☐ 19. Calculate the tank circuit impedance and enter this value as **Z** in the table.

☐ 20. Repeat Steps 15-19 for each remaining frequency listed in the table.

☐ 21. Make a graph of the circuit impedances versus frequencies with the frequency values on the x-axis and the impedances on the y-axis, completing the graph by connecting the points with a smooth curve.

☐ 22. Discuss your results with your instructor; be prepared to discuss the following points:

- If there is a difference between the f_r and f_o, what could account for this difference?
- Why is the current at a minimum when the circuit is operating at resonant frequency?
- Is the role of the tank circuit to block or pass currents near the resonant frequency?
- At resonant frequency, is the Q of this circuit high or low? Why?
- Is the total impedance value greater than, less than, or approximately equal to the value of the series resistor? Why?
- Calculate the bandwidth for the circuit. How does this compare to the bandwidth shown on you graph?

☐ 23. Return equipment and materials to their proper storage location.

Job Sheet 14

Evaluator's comments: ____

Data Table

Frequency	V_C	I_t	X_L	X_C	I_L	I_C	Z
f_r - 30 kHz							
f_r - 20 kHz							
f_r - 10 kHz							
f_r = ______							
f_r + 10 kHz							
f_r + 20 kHz							
f_r + 30 kHz							

Notes:

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AC and AC Circuits
Unit 5

Job Sheet 15—Troubleshoot AC Circuits

Name ________________________________ Attempt Number __________

Date ________________________________ Overall Rating __________

Evaluation criteria	**Rating**
• Troubleshooting procedure was well designed	________
• Equipment was used correctly	________
• Correct problems were identified	________
• Problems were correctly repaired	________

Introduction: For this job sheet, your instructor will provide you with an AC circuit that has one or more problems. Those problems may be defective components, shorts, opens, incorrect wiring, and other problems that an electronics technician is likely to encounter in this type of circuit. Using what you have learned about troubleshooting, component testing, and AC circuit operation, you will be required to design a troubleshooting procedure for the circuit and then carry out that procedure to identify and correct problems in the circuit.

Directions: When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

A. Equipment and materials

- AC circuit or device provided by instructor
- Paper and pencil
- Equipment as required by troubleshooting procedure
- Materials as required by troubleshooting procedure

B. Procedure

☐ 1. Examine device for preliminary troubleshooting assessment.

☐ 2. Define troubleshooting procedure in writing.

☐ 3. Discuss troubleshooting procedure with instructor.

☐ 4. Conduct troubleshooting procedure.

Job Sheet 15

☐ 5. Identify problems and record results of troubleshooting.

☐ 6. Repair equipment to return to operational state.

☐ 7. Verify that repair has returned equipment to an operational state.

☐ 8. Discuss the problem and your response with your instructor.

☐ 9. Return equipment and materials to their proper storage location.

Evaluator's comments: ____

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